DAMOS

DISPOSAL AREA MONITORING SYSTEM ANNUAL DATA REPORT - 1978

Naval Underwater Systems Center
Newport, Rhode Island

New England Division
Corps of Engineers
Waltham, Massachusetts

May 1979

DAMOS

DISPOSAL AREA MONITORING SYSTEM
ANNUAL DATA REPORT - 1978

Naval Underwater Systems Center
Newport, Rhode Island

New England Division
Corps of Engineers
Waltham, Massachusetts

May 1979

TABLE OF CONTENTS

DISPOSAL AREA MONITORING SYSTEM
ANNUAL DATA REPORT - 1978

1. INTRODUCTION

a. Purpose. The Disposal Area Monitoring System (DAMOS) sponsored by the New England Division of the U.S. Army Corps of Engineers has been in operation for slightly more than one year. The primary objective of the program during the first year was the development of a consistant, practical and informative monitoring scheme for 10 dredge spoil disposal sites under the cognizance of the New England Division (figure 1). A second objective was the initiation of programs to increase the capabilities of the Corps of Engineers to monitor such disposal sites and advance the state of the art of dredge spoil studies.

This progress report presents the results obtained during the monitoring effort and describes the status of ongoing work. The structure of the DAMOS as it now exists is presented in figure 2. The New England Division has tasked the Naval Underwater Systems Center (NUSC) with general accomplishment of the program and tasks are carried out either in-house or under contract.

Most physical measurements involving navigation and field work are in-house by NUSC. Contracts for several aspects of the program have been issued to universities and companies in the New England area. Major contracts have been assigned to URI, UCONN, MIT, ENDECO, K-V Associates and others. Over 35 people have major responsibilities in the DAMOS program.

b. Prior Reports. Several informal manuscripts have been circulated under the DAMOS program and presentations have been made at various professional meetings, public hearings and lectures. The most significant of these was a meeting held at the Naval War College in April 1978, that presented the DAMOS program to interested Federal, State, local and scientific agencies. An informal manuscript was distributed at that meeting which discussed in some detail the approach to disposal site monitoring and described the instrumentation to be used. The present report will omit details of instrumentation or techniques except where they have been modified since the April meeting.

2. DATA, SAMPLING AND ANALYSES

a. Arrangement of Data. Most of the data are arranged according to disposal site locations in the form of separate supplements, in order to provide individual sites. Some material, however, is regional in aspect and is not applicable to a specific location. The data in

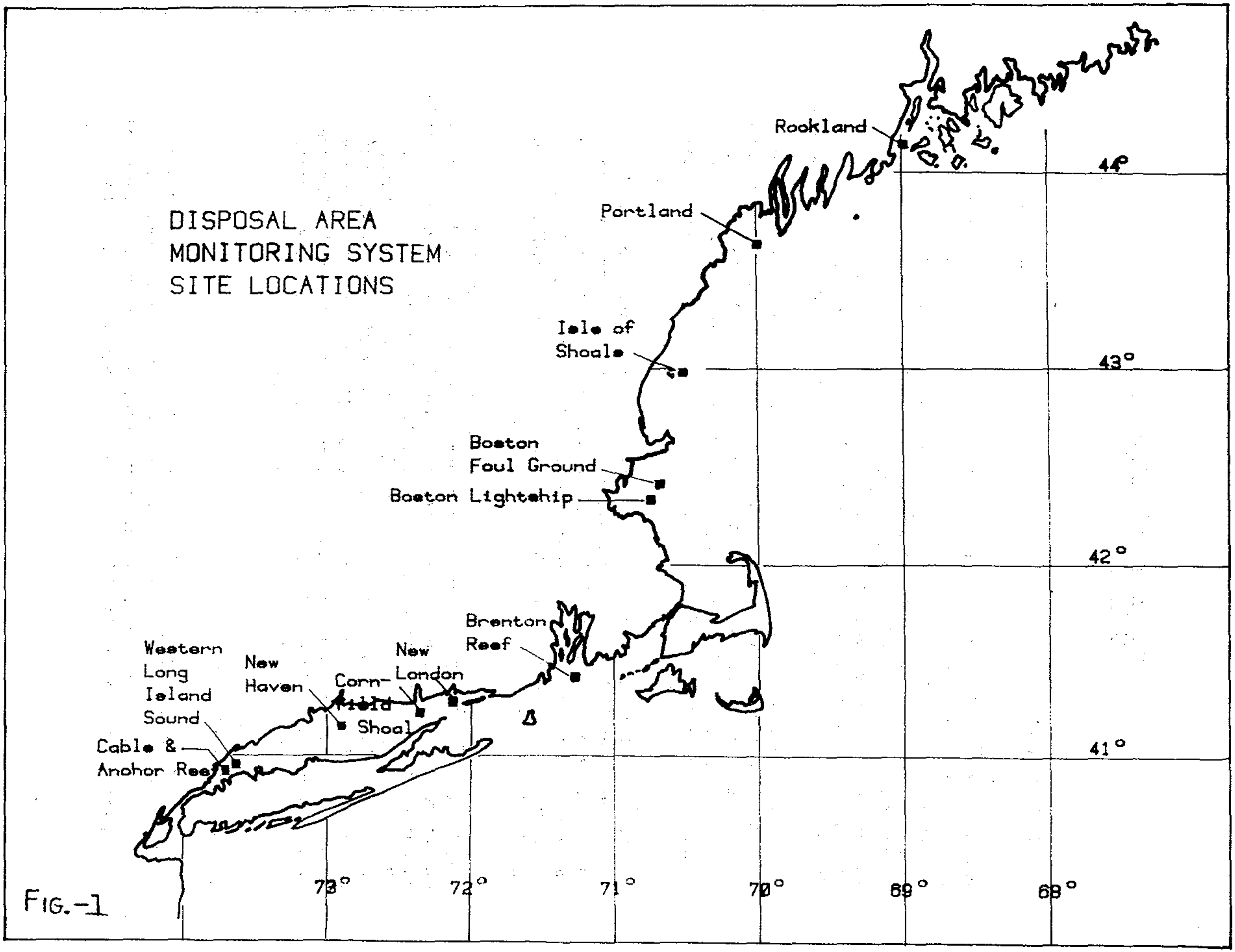

DISPOSAL AREA
MONITORING SYSTEM
SITE LOCATIONS
Rockland
Portland
Isle of Shoals
Boston Foul Ground
Boston Lightship
Brenton Reef
New London
Corn-field Shoal
New Haven
Western Long Island Sound
Cable & Anchor Reef
44°
43°
42°
41°
73°
72°
71°
70°
69°
68°

FIG.-1

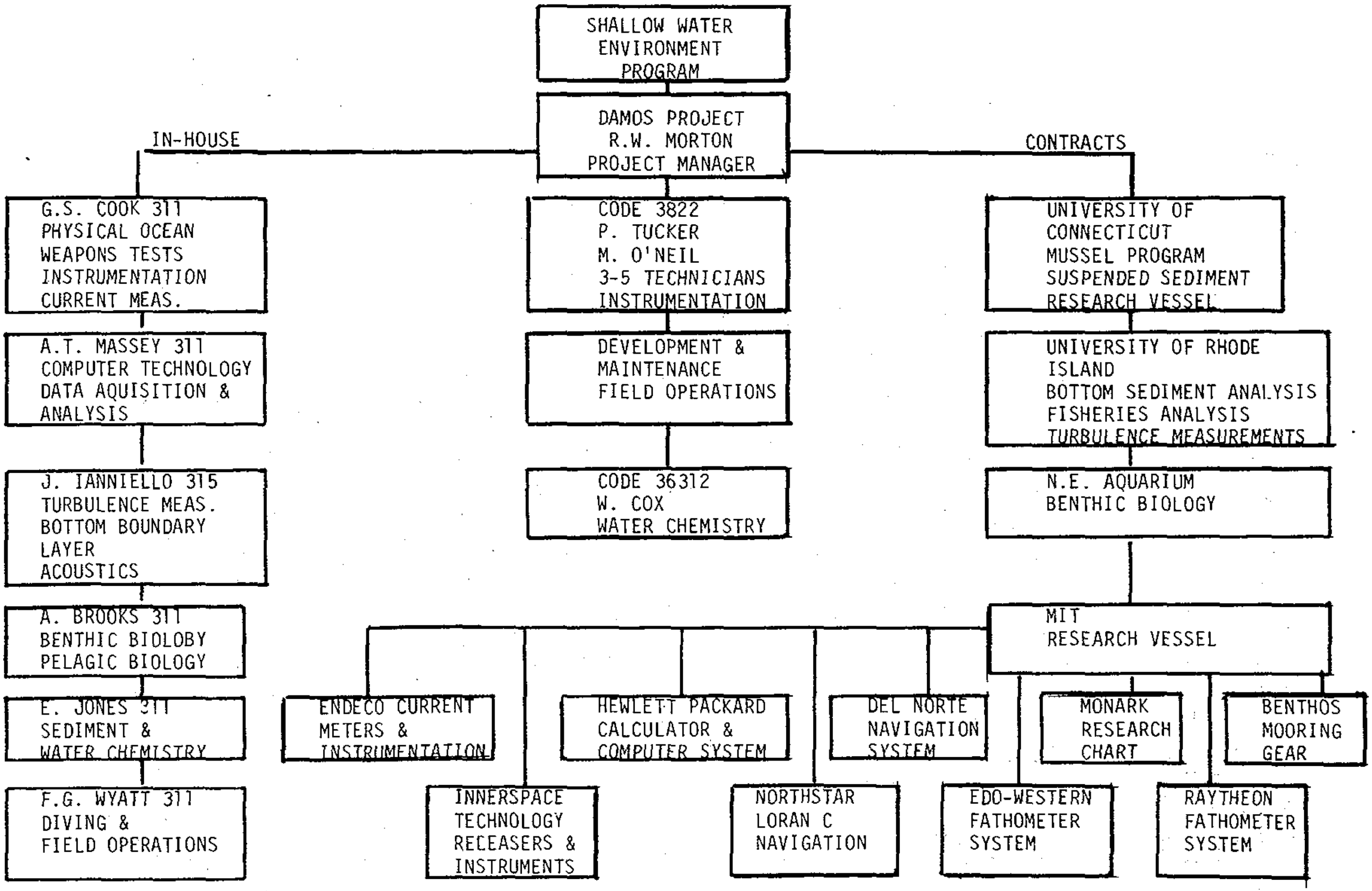

SHALLOW WATER ENVIRONMENT PROGRAM
DAMOS PROJECT R.W. MORTON PROJECT MANAGER
IN-HOUSE
CONTRACTS
G.S. COOK 311 PHYSICAL OCEAN WEAPONS TESTS INSTRUMENTATION CURRENT MEAS.
A.T. MASSEY 311 COMPUTER TECHNOLOGY DATA AQUISITION & ANALYSIS
J. IANNIELLO 315 TURBULENCE MEAS. BOTTOM BOUNDARY LAYER ACOUSTICS
A. BROOKS 311 BENTHIC BIOLOBY PELAGIC BIOLOGY
E. JONES 311 SEDIMENT & WATER CHEMISTRY
F.G. WYATT 311 DIVING & FIELD OPERATIONS
CODE 3822 P. TUCKER M. O'NEIL 3-5 TECHNICIANS INSTRUMENTATION
DEVELOPMENT & MAINTENANCE FIELD OPERATIONS
CODE 36312 W. COX WATER CHEMISTRY
UNIVERSITY OF CONNECTICUT MUSSEL PROGRAM SUSPENDED SEDIMENT RESEARCH VESSEL
UNIVERSITY OF RHODE ISLAND BOTTOM SEDIMENT ANALYSIS FISHERIES ANALYSIS TURBULENCE MEASUREMENTS
N.E. AQUARIUM BENTHIC BIOLOGY
MIT RESEARCH VESSEL
ENDECO CURRENT METERS & INSTRUMENTATION
INNERSPACE TECHNOLOGY RELEASERS & INSTRUMENTS
HEWLETT PACKARD CALCULATOR & COMPUTER SYSTEM
NORTHSTAR LORAN C NAVIGATION
DEL NORTE NAVIGATION SYSTEM
EDO-WESTERN FATHOMETER SYSTEM
MONARK RESEARCH CHART
RAYTHEON FATHOMETER SYSTEM
BENTHOS MOORING GEAR

FIG.- 2

such instances are presented as part of this section. The study of benthic macrofouna exemplifies this kind of situation. Although the specific data relative to each site are provided individually, the cohesiveness of each section requires that it stand alone, hence some repetition of information will be encountered in the individual disposal site reports.

b. Bathymetry.

(1) The Bathymetric Data Acquisition System. The basis for bathymetric surveys accomplished under this program remains the Bathymetric Data Acquisition System (BDAS) interfaced with the Del-Norte trisponder and Edo fathometer. This system has proved to be an exceptional tool, providing the basis for most of the data procurement and analyses in the DAMOS program. It has functioned exceptionally well in the field and also has proved extremely valuable in the processing of bathymetric and current meter data. The heart of the BDAS is the Hewlett Packard 9825A calculator and 9862A plotter. Continued innovations in software have reduced data reduction and analysis time dramatically, so that now it is possible to plot a corrected, contoured bathymetric chart within 1 or 2 hours after completion of a survey. A current meter tape also can be processed in a similar time frame.

(2) Modification of the BDAS. The BDAS system until recently was restricted to use with the microwave, short-range navigation system. Now, however, it has been modified to enable the assessment of the stability of a spoil mound after it has been deposited, by calculating volume changes over a constant, defined area. This will require results from future surveys. Some "dual frequency" bathymetric data utilizing 7 and 200 KHz transducers are presented in this report. These may provide input to volume calculations where spoils are dumped on a hard natural bottom. The subbottom profile gives an indication of the thickness of spoil, deformation of the bottom, and spread of spoil material, however the ambiguities of contouring gentle slopes continue to exist.

(3) Resolution of the System. The resolution of the system was demonstrated dramatically during analysis of the New Haven data. The research vessel normally used for surveying was damaged by drifting ice prior to the 4 February survey at New Haven and when a replacement vessel was provided it was not possible to align the trisponder antenna and the fathometer transducer in a vertical plane. The transducer, consequently, trailed the antenna by 4.5 meters. It was thought that this difference would be negligible but it transpired that the 4.5 meter offset was reflected in alternatingly skewed profiles of the spoil pile, depending on the direction of ship motion. While the offset was easily corrected by adjusting the profiles for the 4.5 meter lag, the need for such an adjustment demonstrated the inherent high degree of resolution of the system.

(4) Repetitive Profiles. Experience now has established that the best method for evaluating the stability of dredge spoil material from bathymetric data is through the use of repeated profiles. Repetition of transects within acceptable limits of navigation and depth error using the predetermined survey configuration provided by the BDAS system is completely feasible. Any changes in profile along a specific transect, consequently, can be attributed to real changes in the bottom. Figure 3 is an example of repetitive profiles across the New London dredge spoil mound from three separate surveys. The vertical exaggeration of twenty-five times shows clearly the repeatability of data and also defines changes that have occurred in the spoil pile itself.

(5) Calculation of Spoil Volumes. We do not feel at the present time that the calculation of spoil volumes based on contoured transects is a valid technique for defining stability or containment of spoils at a disposal site. Even if bathymetric data are closely spaced, corrections for compaction, bottom deflection due to loading, the inherent error in the placement of isobaths on gentle slopes, all introduce uncertainties in the volume calculation several times larger than the differences observed.

(6) LORAN-C. It may be possible, with further refinement of gridding techniques, to assess LORAN-C data and to process information in the same manner. This would increase the potential area of operation of the system by an order of magnitude or more, and the LORAN-C could serve also as a back-up navigation system at each site. Although LORAN-C is not as accurate as the microwave systems, calibration with the trisponder unit permits $20^{\pm}$m accuracies to be obtained consistently at all DAMOS sites. Continued reliance nevertheless on the more accurate (3 to 6 m) microwave systems is necessary for determining the geometry and extent of disposal piles.

(7) NAVSTAR. Future integration of the BDAS, with the NAVSTAR Global Positioning System (GPS) will provide 10m accuracies in three dimensions anywhere on earth. Although this integration is not part of the DAMOS program, it is one example of the technological spinoffs resulting from this program.

(8) Bathymetric Charts. All bathymetric surveys taken in 1978 have been gridded and contoured to produce a pair of bathymetric charts for each disposal site with the exception of Brenton Reef, where one survey was unsuccessful as a result of an error in changing baseline data. The charts in several instances do not cover exactly the same areas as their predecessors, because of change in the survey format as a result of the earlier surveys or because of other inputs.

(9) Profiles. Profiles of all transects are presented additionally to provide background data over larger areas to establish the

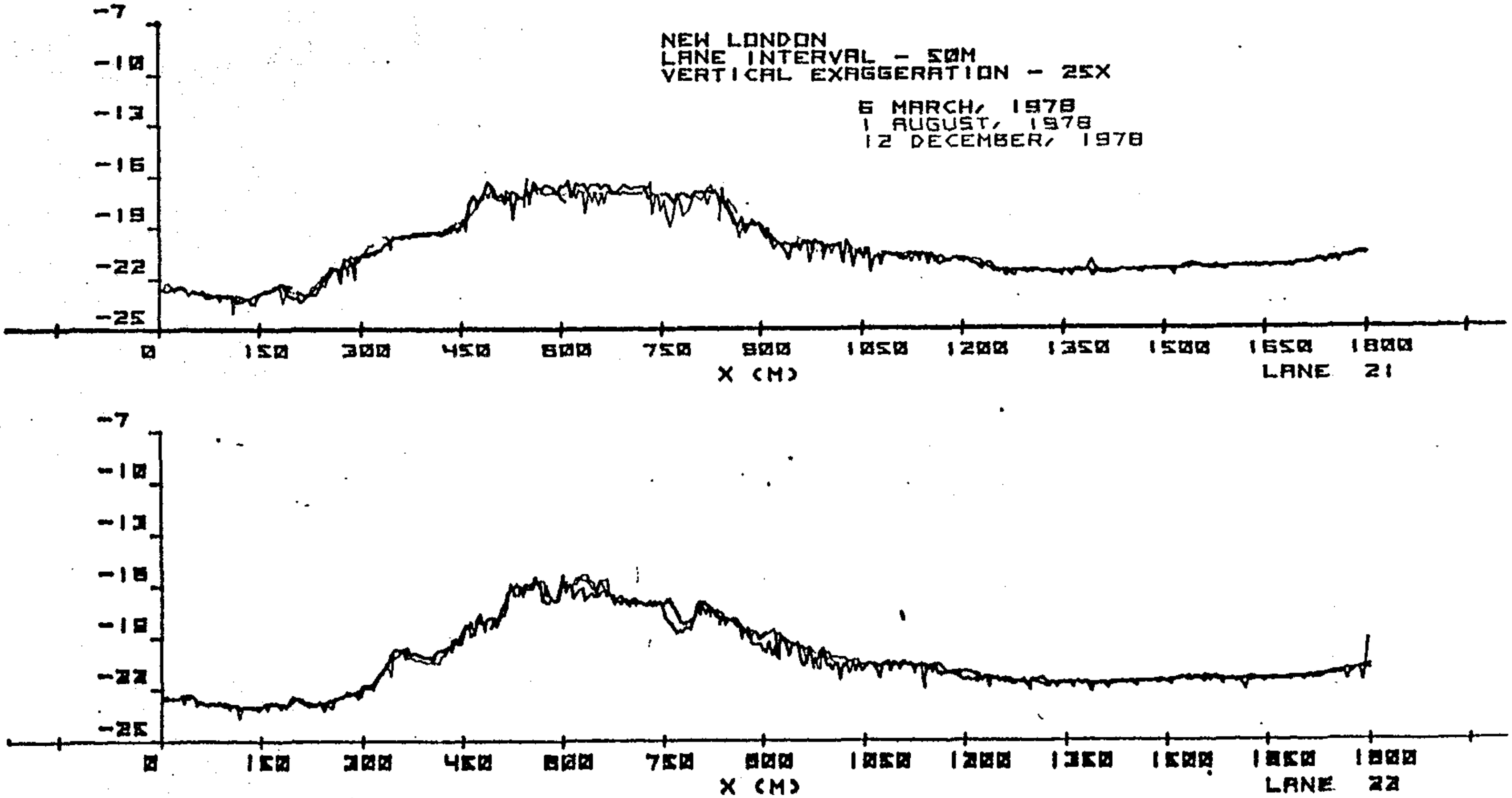

NEW LONDON
LANE INTERVAL - 50M
VERTICAL EXAGGERATION - 25X
6 MARCH, 1978
1 AUGUST, 1978
12 DECEMBER, 1978
-7
-10
-13
-16
-19
-22
-25
0
150
300
450
600
750
900
1050
1200
1350
1500
1650
1800
X (M)
LANE 21
-7
-10
-13
-16
-19
-22
-25
0
150
300
450
600
750
900
1050
1200
1350
1500
1650
1800
X (M)
LANE 22

FIG.-3

accuracy and precision of the surveying system and techniques. No corrections were made to adjust measured depths beyond that required to compensate for draft, sound velocity and tide. Comparisons between surveys at all sites have indicated negligible errors in measured depth except at Cornfield Shoals where a constant effset of approximately 1.5m exists. This offset has not been explained yet. It may be related to sound velocity or draft corrections.

c. Current Measurements.

(1) Meters. The current meters used in the DAMOS program are ENDECO type 174 ducted impeller meters. They record data on an internal magnetic tape which is processed for analysis at NUSC Newport Laboratory. These current meters have functioned well, generally speaking, but in a number of instances the directional information has been partly or totally lost. The current meter tether in one diver verified instance, was found tangled in the mooring wire so that directional information was lost and the speed information was of questionable reliability. In another instance, direction was lost for the first few days of record. This probably was associated with improper ballasting of the near-neutral current meter. (The ENDECO type 174 has an internal leveling mechanism which is activated every 24 hours and will eventually balance the current meter in a horizontal attitude). Still another situation was found of improper magnetic tape head alignment between the current meter and the tape processor. These data, however, can be salvaged.

(2) Fouling. Biological fouling of the current meters was not a severe problem except in Long Island Sound during the summer. The current meters were ordered without antifouling paint so that no source of heavy metals (however small) would be introduced to contaminate caged mussels. The meters have been painted since to avoid the reduction in data quality caused by fouling. It was agreed generally that the leaching of heavy metals from the antifouling paint ought to have insignificant effects on the mussels if the cages were placed a reasonable distance (100m) from the current meters. All other significant components of the mooring system were painted with epoxy paint to reduce exposure of metal to the water column.

(3) Deployment. The original program plan specified that one current meter would be installed to operate continuously at each disposal site. Specifications since have been modified so that meters are placed only at "priority" sites that are currently active or potentially active in the near future because of the unexplained loss of two meters, and persistant problems that have been encountered with acoustic releasers. There are no current meters at the Rockland, Isles or Shoals or Boston Lightship disposal sites at present. All other sites have had current measurements at least during part of the year.

(4) Acoustic Releases. The Innerspace Technology Model 431 Acoustic Releasers used with the current meters and mussel cages have been a constant source of problems and frustration requiring many additional hours at sea to search for and recover moorings with divers and grapnel hooks. Cathodic corrosion, because of the presence of dissimilar metals on the mechanical release mechanism, has prevented tripping in most instances, despite the fact that the electronic-acoustic components of the releasers have functioned at all times. Severe corrosion occurred at all sites resulting in extremely high friction on the release bail, so that the 25 to 30 kg of positive buoyancy exerted by the mooring configuration was insufficient to operate the mechanism even though the release plunger had retracted. DAMOS personnel have worked closely with Innerspace Technology on the development of a modified release mechanism using sacrificial anodes to reduce corrosion and springs to insure mechanical operation. The first of these modified units was installed in September 1978.

The Type 174 Endeco current meters have been installed to measure the containment potential of the dredge spoil disposal sites and to monitor any high energy anomalous events that might occur. The data from these meters provide a unique opportunity to compare, both temporally and spatially the current regime of all New England disposal sites, hence a data analysis and reporting scheme is required that will provide immediate, significant and repeatable quantities for comparison.

(5) Motion Ellipses. An excellent technique for evaluating and comparing current records employs a series of "motion ellipses" that depict: (a) the total observed motion, (b) the tidal component, and (c) residual motions. Each motion ellipse can be defined by its semimajor axis, its semiminor axis and the direction of the semimajor axis. The length of the semimajor axis is equal to the standard deviation (ou) of the velocity component (u) along the direction of maximum energe, which is measured in degrees clockwise from north. The length of the semiminor axis is equal to the standard deviation (ov) of the velocity component (v) perpendicular to the direction of maximum energy.

(6) Horizontal Kinetic Energy. An additional parameter of the current regime is the horizontal kinetic energy expresses as $K_H = \frac{1}{2}P(o^2u + o^2v)$, where P is the density of water, which represents the energy of motion in the horizontal plane. Sites with lower horizontal kinetic energy would tend to be better containment locations.

The current meter data, comprised of speed and direction values sampled and averaged over 2-minute intervals, are read from the current meter with an ENDECO Type 173 Data Transmitter and analyzed using the HP 9825A calculator and 9862A plotter.

Plots of speed and direction (with editing) as functions of time are generated and simultaneously the speed and direction are resolved into (u,v) components (u = true East, v = true North). The arithmetic averages, variances and covariance for the (u,v) components are calculated along with the necessary correlations for subsequent tidal analysis.

The (u,v) probability density distribution (pdd) function and the integrated-over-direction pdd are calculated. The variances and covariance for the (u,v) components are used to define a rotated coordinate system wherein the covariance is equal to zero and the standard deviations for the u and v directions become the semimajor and semiminor axes of a motion ellipse drawn on the speed/direction plots. This motion ellipse represents the total fluctuating energy contained in the record. The horizontal kinetic energy is calculated as the sum of the variances for the velocity components in the (u',v') or (u,v) directions (which are equivalent since the sum of the diagonal elements of the variance/covariance matrix is invariant under rotation of coordinates). The bearing of the semimajor axis of the ellipse represents the direction of the maximum fluctuating velocities and the length of the semiminor axis indicates the degree to which the motion is rectilinear or omnidirectional. The mean velocity, also calculated during analysis, is plotted as a straight line segment terminated with an asterick (*). For both the mean current and motion ellipse, the scale is the same as for the ordinate (speed) axis in the speed vs. time plot.

(7) Tidal Matrix. The tidal matrix consists of correlations between the various pairs of sine and cosine functions for the five tidal components of interest (M2,S2,K1,O1,N2) as well as the steady state (zero frequency) components. This matrix is calculated (dependent on sample length and sampling interval) and used to extract eleven amplitude coefficients. The coefficients are defined such that the resulting tide function is a least squares fit to the original time series. The u and v components of the current are analyzed independently. The tidal coefficients are then used in calculating the variances and covariance for the tidal (u,v) components and subsequently a composite tidal ellipse is calculated via a coordinate rotation (similar to that done for the total fluctuating motion) to bring the covariance to zero. Again, the semimajor and semiminor axes are equal to the standard deviations for the (u,v) components; the direction, however, represents the direction of ebb/flood, and the length of the semiminor axis indicates the degree of rectilinear or rotary tidal motion. The horizontal kinetic energy for the tide alone is calculated using the standard deviations (σu, σv) of the tidal components.

(8) Elevated Velocities. The tidal ellipse and the horizontal kinetic energy are indications of the normal current regime existing at a disposal site. The most significant factors affecting the containment or dispersal of spoil material, however, are the higher speeds associated with that regime. In order to examine these higher speeds the residual current is determined simply by subtracting the tide computed from the least squares analysis from the observed data. Since the tide is statistically independent from the residual time series, the variance and covariance for the residual time series can be calculated simply as the difference between the corresponding values for the total time series and the tidal functions. These values indicate the extent to which the

total motion is composed of tidal flow or other, essentially random, motion. In this case, the horizontal kinetic energy of the residual motion quantifies the importance of the random events. A motion ellipse for the residual current also can be determined which would generally have only small differences between the semimajor and semiminor axes if the motion is truly random.

It is possible to examine the highest velocities encountered in the current regime by combining all these motion ellipses and the probability density distributions. A quantity defined as the 10 percent highest speed has been established to characterize these maximum velocities. This speed is the arithmetic average, calculated from the probability density distribution of the highest 10 percent (or as close to 10 percent as allowed by the pdd) of all measured speeds. Although these values do not consider direction, virtually all of the higher speeds result from velocity components along the direction of maximum motion owing to the significance of the tidal flow relative to random motion.

(9) Peak Tidal Velocity. It is essential to determine the effect of the tidal motion through the use of two quantities defined as the peak tidal speed and the average maximum speed since the tidal motion is a major contributor to the maximum velocities. The peak tidal speed is the maximum value that the speed can reach based on the computed tidal coefficients and would only occur when all (five) time varying components were simultaneously in phase. A more realistic "peak" could be calculated using the two dominant components (M2 and N2) only, which would be realized approximately once every 27 days. The difference, however, is small because the contributions from the remaining components are nearly negligible for all locations analyzed thus far.

(10) Average Maximum Velocity. The average maximum speed represents typical maximum tidal speeds occurring on each flood or ebb and is defined as the amplitude of a hypothetical sinusoidal tide having the same kinetic energy as the actual tide. Note that for all tidal calculations, the mean current is treated as a component.

(11) Anomalous Events. Finally, the speed/direction time series are subjected to an evaluation with respect to locating and defining single events, usually storm and wind generated anomalies that can increase significantly the stress exerted by the fluid motion on the spoils. These anomalous events are correlated with meteorological data, for each site, obtained quarterly from the National Climatic Center in Asheville, North Carolina. The data resulting from these analytical techniques are tabulated for each record to provide an assessment of the temporal and spatial motion at each disposal site. The tabulated data, particularly the horizontal kinetic energy, then can be used to compare the measured current regimes. Other factors such as the relative importance of tidal and random motions also can be used to describe the current.

(12) Ranking of Sites. A relative indication of the containment potential for all sites can be obtained by ranking the sites in decreasing order of horizontal kinetic energy contained in the total observed current time series (table 1). It is apparent from these data, that Cornfield Shoal is by far the most dynamic site, having kinetic energy nearly twice that present at New London, the latter having in its turn twice that of any other site. A close look at the data, however, indicates that more than half of this kinetic energy is in the residual currents and that the tidal energy at New London is actually greater than at Cornfield. The high value of kinetic energy may in reality be an artifact of a recording problem in the current meter, producing artificially high residual values and a record with many spikes of high current speed. The similarity between the tidal energy at New London and Cornfield might mean that in fact they have quite similar current regimes. The proposed Portland disposal area has the lowest kinetic energy by a factor of ten. One reason for this is readily apparent if one compares the percentage of tidal energy in the total motion for all sites (table 2). With the exception of Cornfield Shoals (which has the possible recording error) the Portland site has the least tidal energy relative to the total motion. When considering this with the deeper depths of Portland which would result in reduced residual energy the Portland site is an extremely low energy regime compared to the others. The velocities at Portland, because of a lack of tidal dominance in the current, may be harder to predict on a percentage basis than those at New Haven or Western Long Island Sound where the tide is obviously the major driving force of the current.

(13) Comparison of Northern with Southern Sites. It appears, in general, that the solution sites are significantly more dynamic than the northern sites with respect to current motion. It is doubtful that future current velocity data from Rockland, Isle of Shoals, or the Boston Lightship will alter this trend. The effect of wave action, however, is not measured by such tethered current meters and, although the depths of the northern disposal sites are significantly greater than the southern sites, this fact must be considered.

(14) Relationship of Storm Stress to Bottom Currents. Correlation between atmospheric storm conditions and current velocity near the bottom has been observed both in Long Island Sound and at Portland. The contribution of such a forcing function to an increased bottom stress is real, but has not been measured by these instruments. It is anticipated that stress measurements made during storm periods by the BOLT system will be correlated with current data at several sites during the coming year. The possibility of defining accurately the containment potential of disposal sites by current data in the near future appears to be extremely high.

d. Boundary Layer Turbulence System.

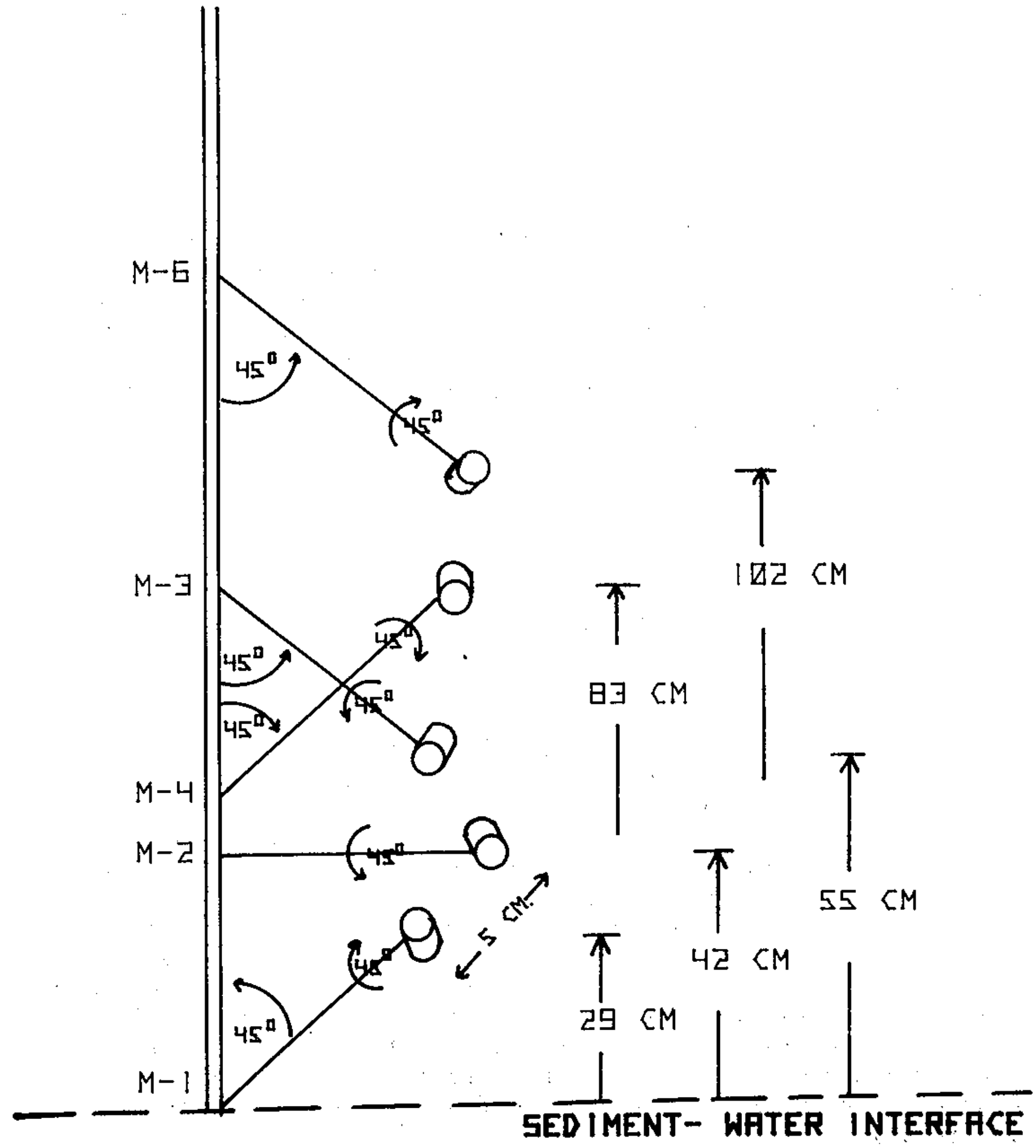
(1) Experimentation. The development of the Boundary Layer

Turbulence (BOLT) system has progressed during 1978 to the point where the instrument is ready for field operation. A test of the system in clear southern water was conducted in March 1978. It provided confirmation that the unit can be deployed in a variety of configurations depending on expected conditions, and that the data obtained from each configuration can be recorded and analyzed. The first deployment of the BOLT system on a dredge spoil disposal site occurred at the New London Disposal Site on 20 September 1978 at the start of the flood tide. Data were collected at an 0.2 second rate continuously for six hours, thereby allowing a detailed look at both the accelerating and decelerating portions of the tidal cycle. The purpose of the measurement was to check the operation of the electronics package, to confirm the suitability of the proposed current meter configuration, to observe the BOLT system operation in a tidal regime, and in general to gain further experience deploying the unit.

(2) Arrangement of Meters. Two of seven current meters had not returned from minor servicing at the time of the test so only five meters were available. It meant that three dimensional measurements (and hence shear stress) could be determined at only one level. The five available meters were configured as shown in figure 4. The bottommost meter (meter 1), was tilted up from the main support pole at 45° and then the meter face was rotated 45° from the vertical into the plane of the paper. The second meter from the bottom (meter 2) was extended perpendicularly from the main support and the meter face was rotated 45° from the vertical out of the plane of the paper. The third meter from the bottom (meter 3) was angled down 45° and rotated 45° from the vertical out of the plane of the paper. The bottom three meters as shown are the preferred configuration when the mean flow may reverse. These meters may be assumed to be sampling the turbulent fluctuations having wave lengths of greater than 5-10 cm at the height of the middle meter. This configuration will be the principal one used for transient event monitoring.

(3) Deployment. The BOLT system was lowered from the ship and oriented by divers so that the expected mean flow would be into the plane of the paper (figure 4). The bottom of the support pole was observed to be just level with the surface of the mud. The bottom was reported as rough and clumpy with the clumps having dimensions of approximately one meter. The divers reported, upon retrieval of the system after four days deployment, that the entire system had settled approximately 10 cm into the mud. Iron fillings were observed on the magnets which are inset in the current meter impeller blades. Both the settling of the BOLT system and the accumulation of iron fillings on the magnets (which may upset meter calibrations) are problems to be resolved.

(4) Problems. The raw data were transferred following retrieval of the unit from digital cassettes used by the BOLT electronics



DUCTED METER CONFIGURATION
NEW LONDON DISPOSAL SITE
SEPTEMBER 20, 1978

FIG. -4

to a computer compatible magnetic tape. They then were plotted and examined for problems. The data showed none of the spiking behavior that had plagued earlier tests indicating that this problem, which had been traced to a power supply deficiency, had been solved. Only two problems remained. The first was that the maximum current had been set for 50 cm/sec rather than 100 cm/sec to gain greater resolution and currents at one or two of the meters exceeded 50 cm/sec during the peak portion of the tidal cycle. This resulted in some of the data being strongly clipped. The other problem occurred when meter 3 stopped rotating for approximately one hour during the middle of the test. The cause of this is not known but it is speculated that seaweed fouled the meter. That the meter did clear itself and began rotating again with no apparent harm was encouraging.

(5) Typical Plots. Typical plots of the raw data from meters 1, 2, and 3 are shown in figures 5 and 5A. Figure 5 corresponds to data taken during the accelerating portion of the tidal cycle and figure 5A, to data taken during the decelerating portion. Note that the currents generally are well in excess of the threshold of the meters (about 2 cm/sec). Some clipping at 50 cm/sec can be seen in figure 5A meter 3, between 80 and 100 seconds.

The raw data were then converted to u, v, and w components using the relations

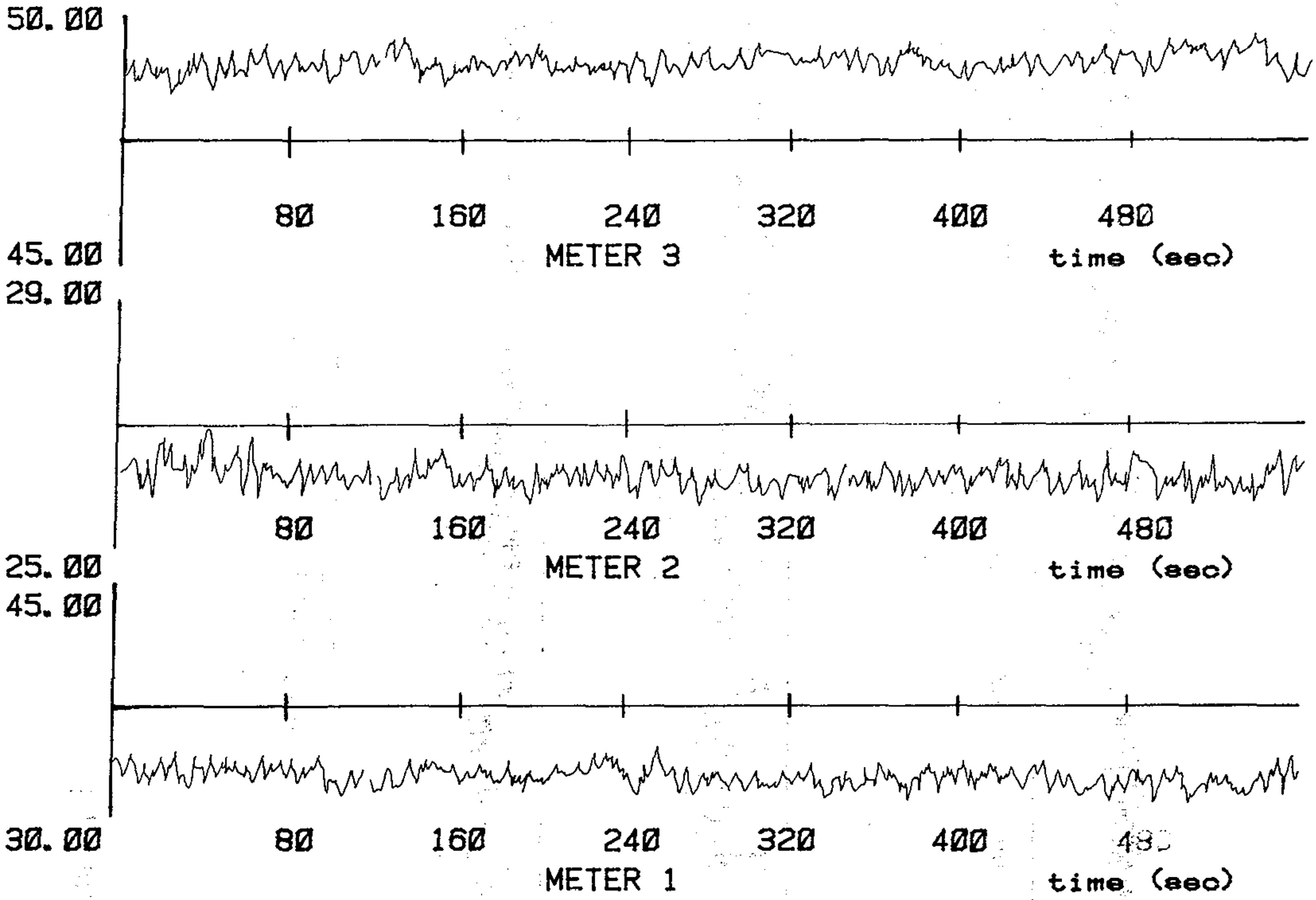
$$u = u_1 + \sqrt{2}u_2 + u_3$$

$$v = (\sqrt{2}-1)u_1 + 2u_2 - (1+\sqrt{2})$$

$$w = u_3 - u_1$$

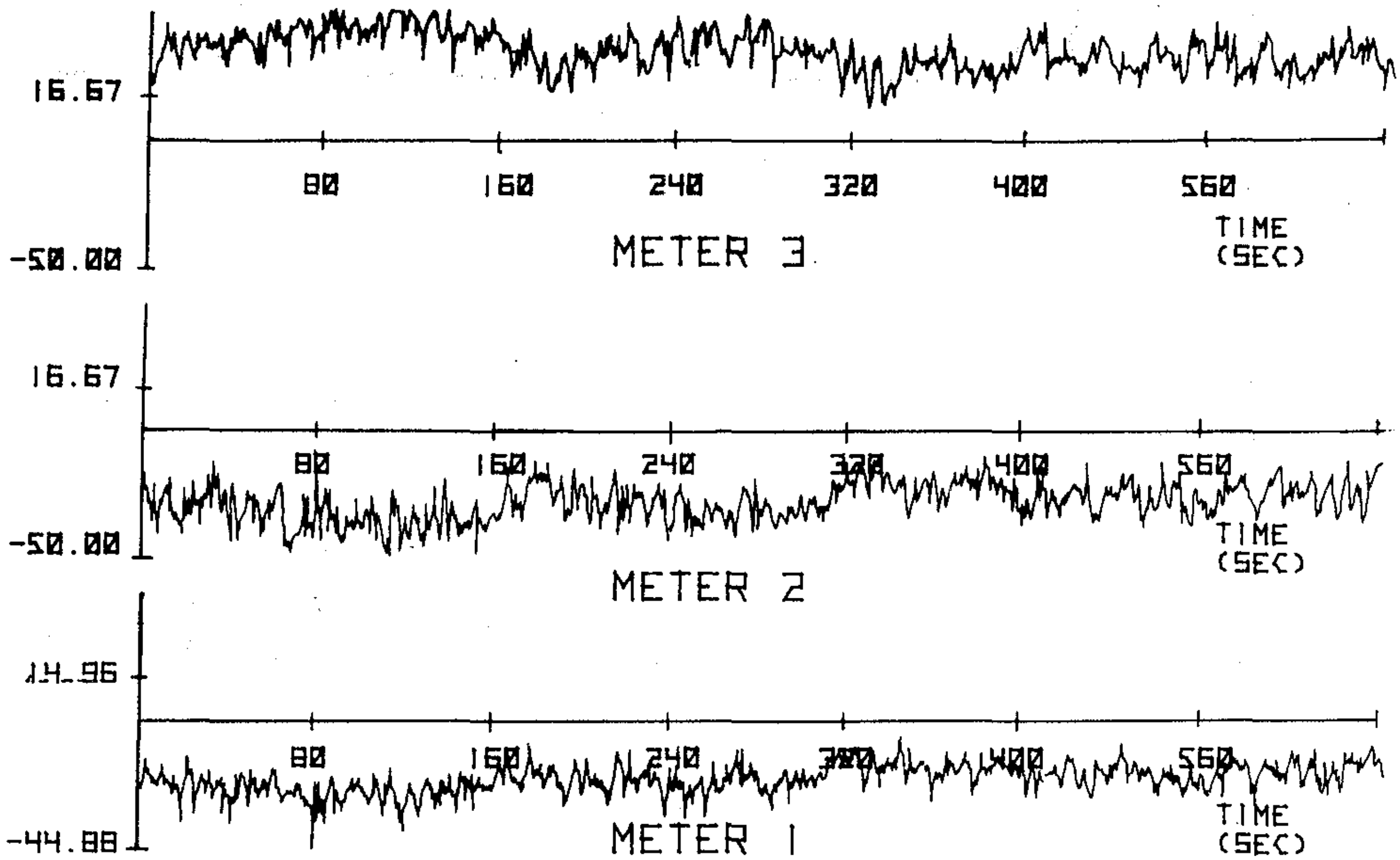
which are determined from the geometry of the meter configuration. u, u_2, and u_3 are the raw current values measured by meters 1, 2 and 3 as shown in figures 5 and 5A. Observe that no correction is made for the deviation of the off-axis response from a cosine function of the individual meters. This additional calculation will be included after further meter calibrations are made. u, v and w are instantaneous values of the horizontal and vertical components of the current, defined with respect to the vertical plane through the current meters, the u direction being taken as normal to the plane. Typical results for u, v and w are shown in the bottom three plots of figures 6 and 6A. The data in figure 6 are for the accelerating portion of the tidal cycle (they correspond to the raw data shown in figure 5); the data in figure 6A are for the decelerating portion of the tidal cycle (they correspond to the raw data in figure 5A).

(6) Interpretation. The instantaneous shear stress is given by $-pu^1w^1$ where p is the density of water, and u^1 and w^1 are the horizontal and vertical turbulent velocity fluctuations about the mean current.



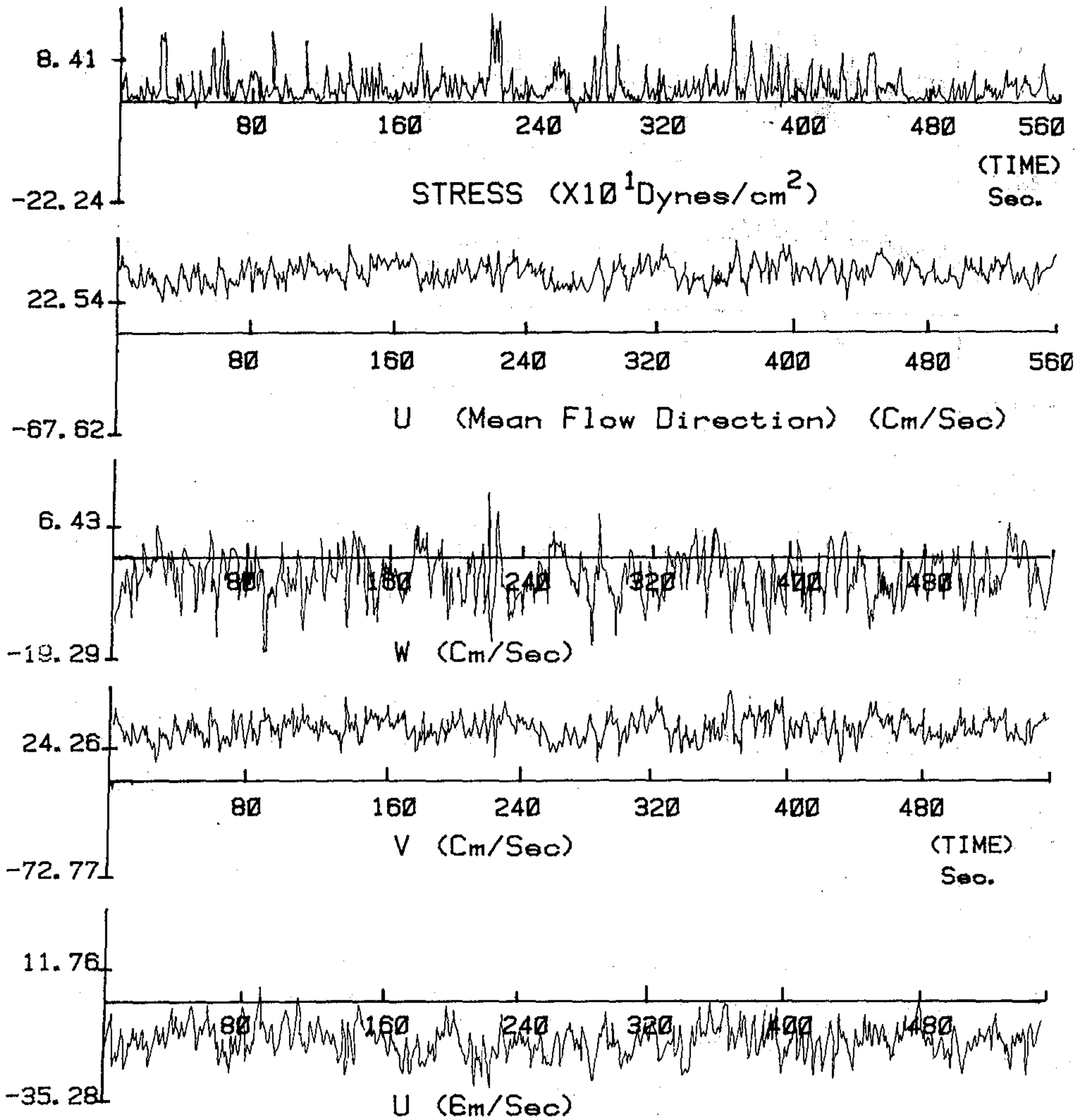
BOLT RAW DATA
ACCELERATING TIDAL CURRENT

FIG.-5A



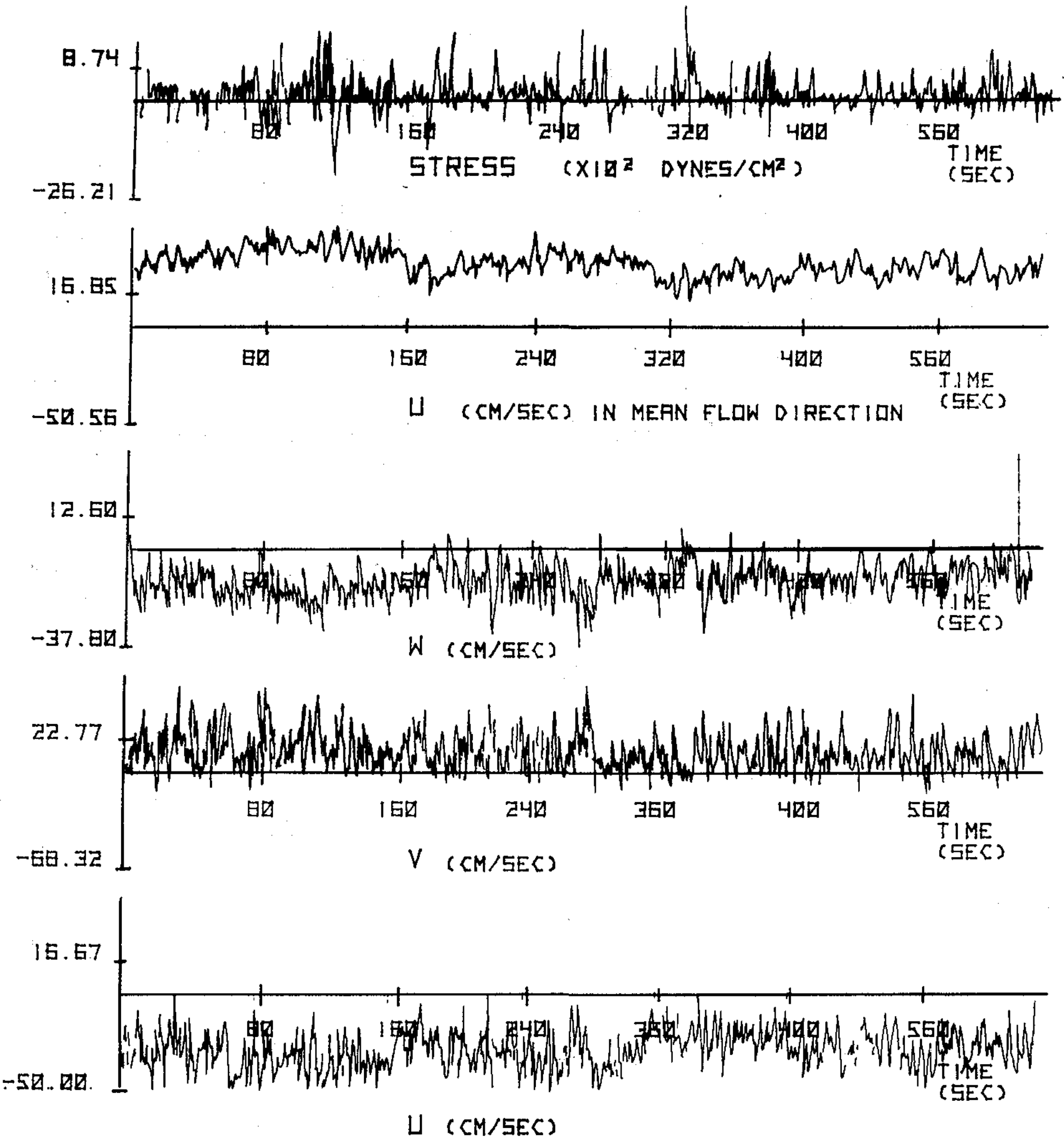
BOLT RAW DATA
DECELERATING TIDAL CURRENT

FIG.-5B



INSTANTANEOUS CURRENT & SHEAR STRESS
ACCELERATING CURRENT

FIG.-6A



INSTANTANEOUS CURRENT & SHEAR STRESS
DECELERATING CURRENT

FIG.-6B

To calculate u^1 and w^1, we first must align the u axis with the mean current via two coordinate rotations.

Notice first from figures 6 and 6A that the average value of w over the 10-minute interval shown is not zero. This means that either the bottom was not level, the mounting pole was not precdsely vertical, or the current meters were not positioned to the exact angles shown in figure 4. Also note that the horizontal current is not aligned with the u axis as defined by the perpendicular to the plane of the current meters. Thus, to align the u axis with the mean current the horizontal axes must be rotated so that the new u axis is aligned with the mean flow direction in the horizontal; then the axes are rotated in the vertical so that the average value of w in the new coordinate system is zero. This ensures identification of the mean flow direction. The turbulent u^1 fluctuations then are found by subtracting the average value of u in the mean flow direction from the instantaneous value. The turbulent w^1 fluctuations are given directly by the instantaneous values of w in the rotated coordinate system.

(7) Selection of Averaging Time. The averaging time must be selected so that it is long enough to give statistically reliable results (it must include many typical events) but it must be short enough so that the process can be considered stationary during the interval. When dealing with tidally induced turbulence, an averaging time of 10 minutes meets these criteria. The complete record thus is broken into a series of adjacent 10 minute segments (10.67 minutes actually) and the coordinate rotations discussed above have been performed for each of these 10 minute segments.

(8) Intermittancy Phenomena. Typical results are indicated in the top two panels of figures 6 and 6A, where the instantaneous value of u in the mean flow direction and the instaneous shear stress are shown. Note that the instantaneous shear stress has peak values greatly in excess of its average value, showing some evidence of the bursting or intermittancy phenomenon.

(9) Average Stress. The average velocity in the mean flow direction and the average shear stress for a series of continuous 10 minute segments for both the accelerating and decelerating portions of the tidal cycle are presented in table 3. These average values of stress are generally higher than the typical values of about 4 dynes/cm^2 reported earlier at the New London site. The earlier values were computed by a different technique using different insturments and will require detailed comparison, which is one of the principal goals of BOLT measurements.

A possible source of error in present stress calculations is an internal misalignment of the axes of the current meter configuration (as opposed to a rotation of the axes). Errors resulting from a rotation of axes are corrected by processing as discussed above. Internal misalignments, however, cannot be corrected. It can be shown, for example, that if the effective u axis is not exactly perpendicular to the w axis, but rather is offset by a small angle Θ, then the error in the stress measurement is given by $\bar{u}^2 \sin\Theta$. If $\Theta = 5^{\circ}$ and $\bar{u}^2 = 100\ cm^2/sec^2$ an error as large as 10 $dynes/cm^2$ is possible. This illustrates the great importance of precise axes alignment. It has been estimated that the axes alignment must be accurate to 0.5° to make satisfactory shear stress measurements. Axes misalignment also can lead to the appearance of bursting or intermittancy in the stress plots. Interpretation of the observed bursts as true turbulent bursting must await positive knowledge that the meters are precisely aligned.

(10) Further Tests. The New London tests were intended as a check on the electronics system and as a trial run to discover problems with the proposed meter configuration in a tidal regime. The test was satisfactory on both counts. It is intended now to check the meter configuration in a wave dominated regime (probably at Portland) and to conduct preliminary calibration of the meter configuration in the MIT tow tank. If neither test shows serious problems we will proceed to have precisely machined meter mounts constructed so the necessary accuracy in the meter alignment can be assured. Practical problems that have been discovered are: the settling of the BOLT system into the mud, thereby making it uncertain at exactly what level we are making measurements (about 10 cm in 4 days was observed at New London); the accumulation of iron filings on the current meter magnets (possibly affecting the meter calibration); and the occasional stopping of the meters presumably because of fouling by seaweed.

e. Laboratory Shear Stress Measurements

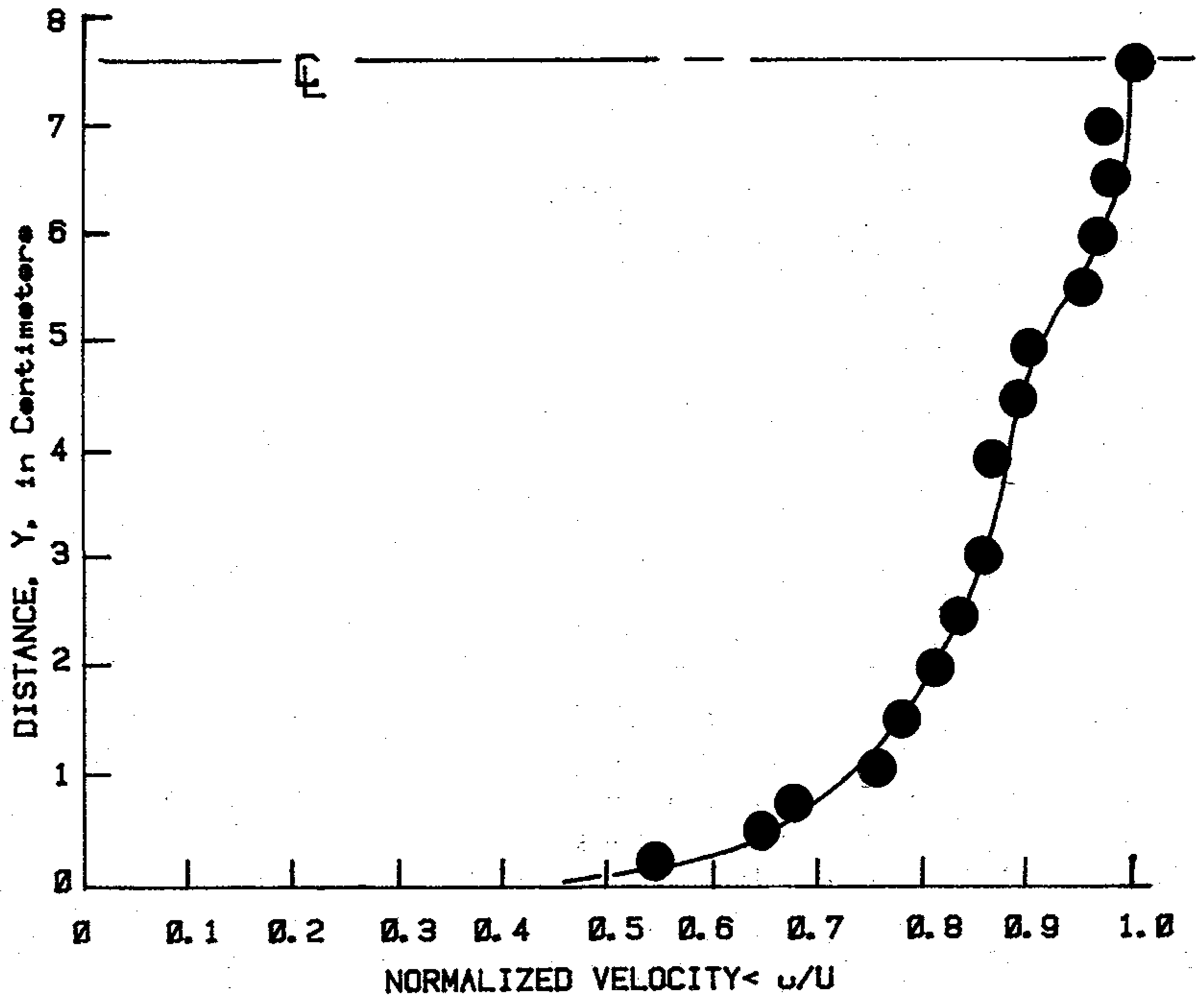
(1) Flume Measurements. Measurement of the velocity profile, turbulent intensities and relative turbulent intensities were made in the working section of the water tunnel using a hot film anemometer in order to investigate the relationship between in situ turbulent flow and that created in the University of Rhode Island water tunnel. The shapes of the velocity profiles were atypical, indicating that additional turbulence, probably created by the propeller pump, is present at the center of the flow. The turbulent intensity plots were similar to those found in the literature with some scatter. This is believed to be attributable to possible surging within the tunnel. The turbulent intensity as well as the relative turbulent intensity increased with increasing velocity. The turbulent intensity was higher near the boundary in all instances. Attempts were made initially to use a Pitot tube and pressure transducer to measure the velocity profile within the tunnel. It was not possible however to separate pressures due to velocity changes from the extrneous pressure fluctuations occurring within the tunnel.

(2) Hot Film Anemometer. The hot film anemometor is a resistance-temperature transducer. The film is heated above ambient by passing an electrical current through a nickel film. The flow of fluid over the heated film cools it by forced convection (assuming the water velocity is high enough). A feedback system is used to supply additional current (power) to keep the temperature of the probe constant in the constant-temperature (constant resistance) mode of hot film anemometry. The amount of power supplied is indicative of the velocity of the water flowing over the probe and the current fluctuations are an indication of the fluctuating velocities.

(3) Frequency Range. The advantages of the hot film approach are the sensor's small size and the system's frequency response. The frequency range of hot film anemometers, 10 to 50 KHZ has been shown by Richardson and McQuivey to be typically 70 to 100 times greater than the frequencies encountered in water. The disadvantages include: instability (caused by air dissolved in the water both short and long term) contaminants, and chemicals.

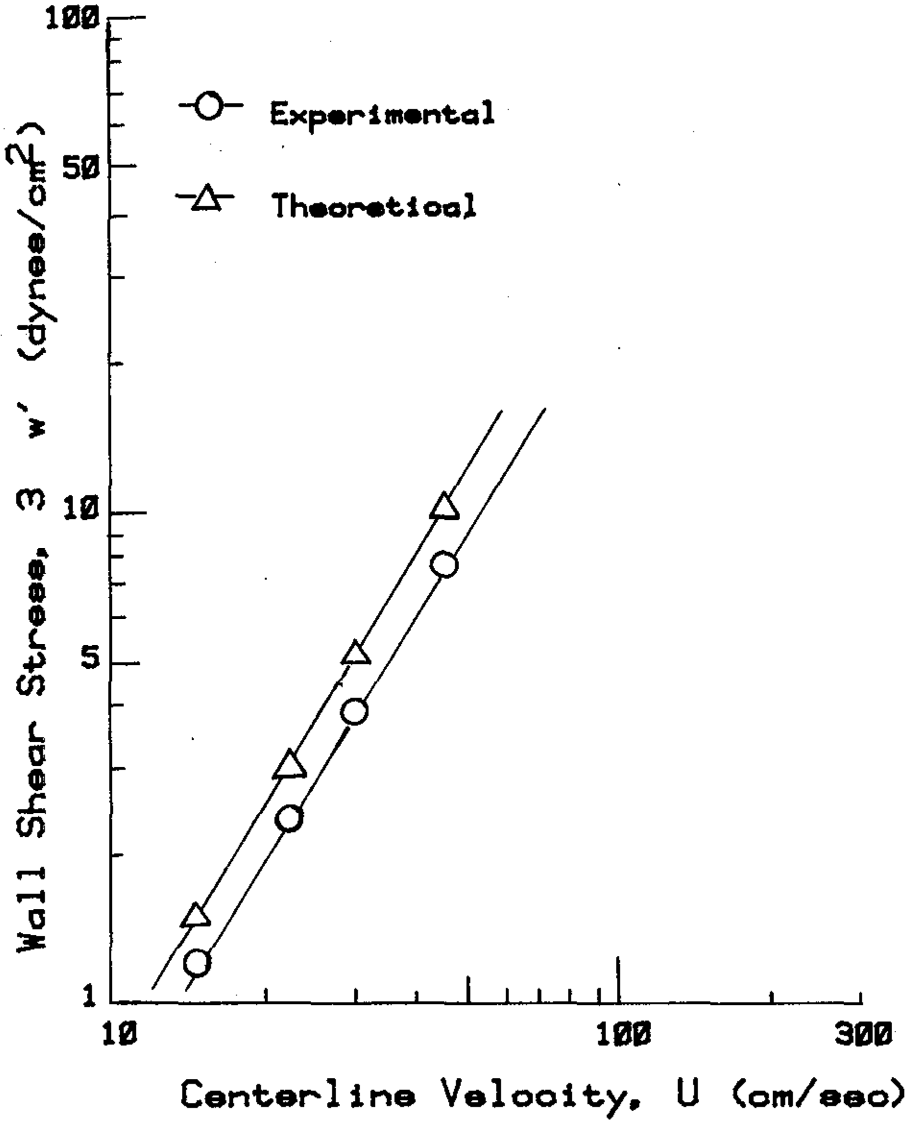
(4) Velocity Profile. The hot film probe was used at average centerline velocities of 15, 22.5, 30 and 45 centimeters per second to determine the velocity as well as the turbulent intensity profiles of the ducted flow. To accomplish this the probe was initially placed near the bottom (0.25 centimeters) and then elevated in 0.25 centimeter increments up to one centimeter and in 0.5 centimeter increments thereafter. The constant voltage as well as the RMS value of the fluctuating component was recorded at each elevation. Velocity profiles were obtained from this information. A typical velocity profile is shown in figure 7. The profiles in this figure, (which is atypical for turbulent ducted flow) appear to be well behaved near the wall, but near the center of the flow the boundary layer is disturbed. It is believed to be caused by turbulence produced by the tunnel's propeller pump. The effect is most pronounced at the highest average centerline velocity.

(5) Shear Stress Values. The shear stress values determined by measuring the velocity profiles and using the Caluser plots, T_c, those determined from purely theoretical considerations, T_t and those measured with the shear tray, T_m are tabulated in table 4. These wall shear stresses are plotted as a section of centerline velocities in figure 8. The measured values (shear tray) differ from those obtained from the Clauser plot by about 10 percent (the percentages are given in the table). The theoretical values, determined directly from the law-of-the-wall, are within essentially 25 percent of the measured values. This 25 percent discrepancy is equivalent to a centerline velocity that is 10 percent too great. From the velocity profiles it can be seen that this is entirely possible due to the additional turbulence in the core of the flow. The closer agreement between the measured and Clauser derived shear stresses possibly is due to the Clauser plots compensating for the atypical velocity profiles.



DISTANCE-NORMALIZED
HORIZONTAL VELOCITY RELATIONSHIP

FIG.-7



WALL SHEAR STRESS
CENTERLINE VELOCITY RELATIONSHIP

FIG.-8

(6) Relative and Maximum Intensities. The relative intensity can be obtained by dividing the turbulent intensity by the centerline velocity (in this case since the measurements were made at the center of the duct). The relative intensity at the centerline and the maximum obtained at each velocity are given in table 5.

f. Undisturbed Surface Sediment Sampler. Spoil samples have yet to be obtained and analyzed in the URI water tunnel, owing to delays in the fabrication of the Undisturbed Surface Sediment Sampler (USSS). The unit should be deployed at the northern sites in the near future. The USSS samples spoil to a depth of 5 cm, as originally designed. This, however, most likely would provide an unstable sample and probably would be too shallow to account for microtopography. The unit, therefore, has been modified to increase the sample depth to 15 cm. The entire assembly has been gimballed in order to ensure alignment of the subassembly with the sea floor.

Other modifications to the original design include replacement with weights of the rotary torque drivers required to drive the cutting blades. The legs on the transport stand have been made removable so that in the event of damage a single leg can be replaced. The deck stand has been replaced by a mobile transporter, since some form of transport mechanism is required to remove the subassemble from the transport frame.

The sampler subassembly will be anodized by a special process which results in a Teflon-impregnated hardened face with increased lubricity in order to provide corrosion protection. Other components will be anodized with chromate treatment.

g. Surface Sediment Chemistry

(1) Collection of Samples. An extensive program of sampling and chemical analysis of surface sediment has been initiated in order to examine the background levels of heavy metal concentrations in dredge spoil disposal sites, surrounding regions and potential dredging locations. Procedures for the analysis of these samples were described in previous reports.

The samples were collected from two major areas: Rockland, Maine to Boston, Massachusetts and Norwalk, Connecticut to Brenton Reef, Rhode Island. Two sampling sets are available from the Norwalk-Brenton Reef region while only one set is available from the Northern New England area. The data are summarized in table 6. Extensive sampling at the New London disposal site has been accomplished and will be continued by DAMOS in the future. Specific data, however, will not be presented here since they are readily available. General results from New London will be discussed as they relate to the overall regional picture.

(2) Interpretation of Data. The interpretation of the data presented in table 6 is extremely difficult because of the variability encountered. When viewed in total, however, it has been observed that dump sites usually are higher in metal concentrations than the surrounding areas and that open, previously unspoiled areas generally are substantially lower than near-shore, active sites.

(3) Iron Reference. Plots have been prepared comparing the data of several metal concentrations to iron in an effort to demonstrate the regionalism and distinctions between active and non-active sites. Iron was used as the basis for comparison because of its lower sample to sample variability and ubiquitous nature, it being the highest in concentration compared with all other metals determined. A line is drawn on each iron to other metal plot with a slope based on data from the best background data available. The slope is estabilished by the "clean data". Slopes for Cr, Cu, Hg, and Zn have been established as .05, .10, 12, and .025 x 10^4, respectively. Points falling below the line indicate a greater proportion of the given metal, while points above the line are proportionately greater in iron or less in the given metal. Points higher on the plot or farther to the right, are higher in total concentration of Fe or other metals.

(4) Summary Plot. A summary plot of all samples is presented in Figure 9. A close examination of this plot reveals several interesting results. Samples from disposal sites in Western Long Island Sound, including New Haven, fall well below the "clean data" lines. Other samples falling into this category are some disposal site dredge spoil and sediments from harbor areas. In particular, one sample from the Cornfield Shoals disposal area is greatly enriched in Cu, Cr, and Zn compared to all other Cornfield Shoals samples, and appears to be an excellent indicator of the presence of dredge spoil at the site even though no indication of spoils can be seen through the use of bathymetric techniques.

(5) "Clean" Areas. Clean areas such as Isle of Shoals, Brenton Reef, Cornfield and Portland have data points which fall above or about the "clean data line". Introduction of spoils in these areas, such as disposal of Piscataqua River Material at Isles of Shoals should be traceable using this technique. This procedure would be more difficult, however, if not unlikely in areas of western Long Island Sound. There appears to be a definite distinction between Northern New England sites and Western Long Island Sound sites. Some points as would be expected do not fit the above pattern.

The usefulness of iron vs. metal plots may become more clear as more data are accumulated. It is expected that surface sediment metal concentrations will shift from above the background based lines to below as inactive or virgin sites are used for dredge spoil disposal, i.e. become enriched in heavy metals with respect to iron.

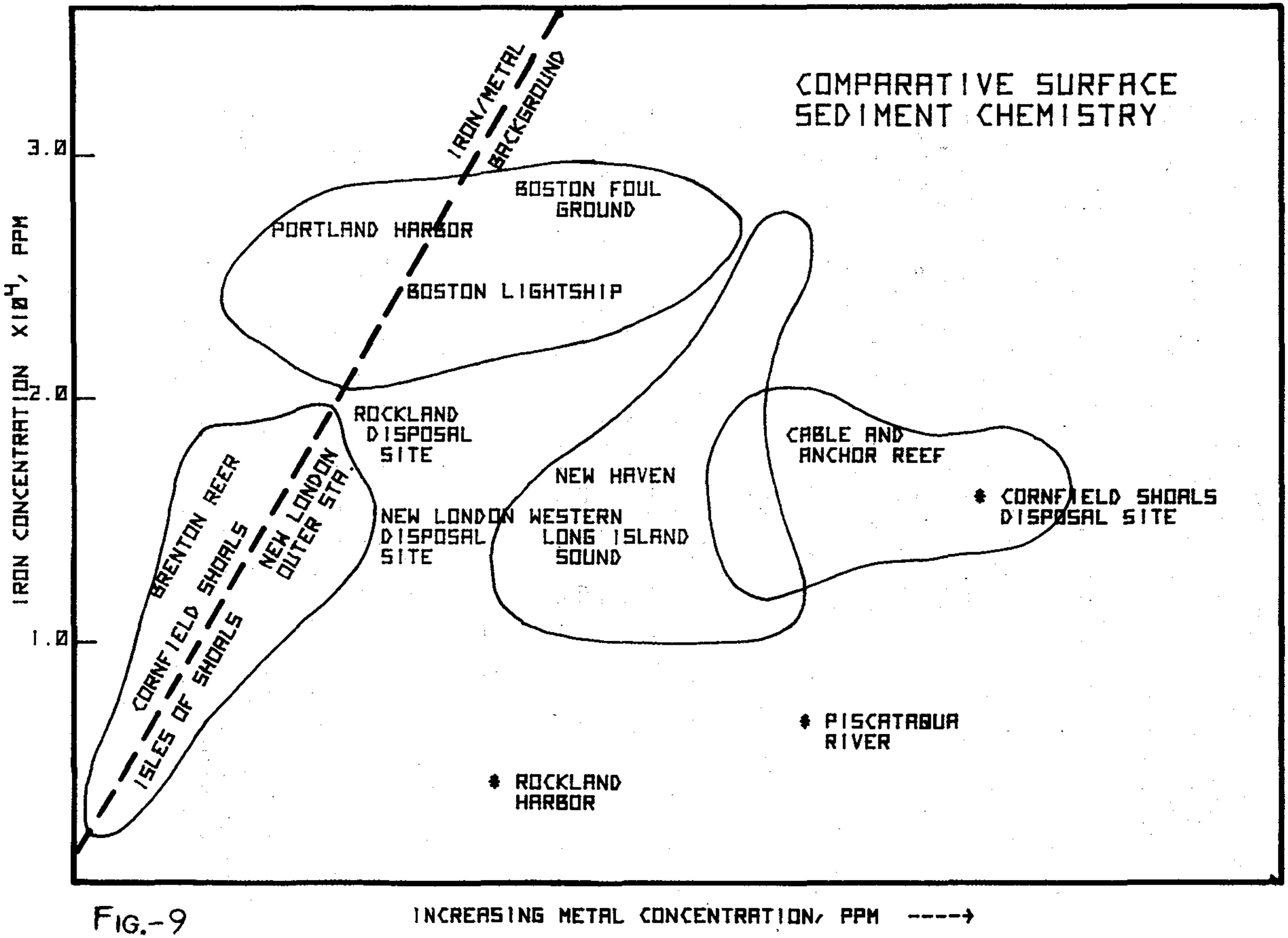

COMPARATIVE SURFACE SEDIMENT CHEMISTRY
IRON/METAL BACKGROUND
3.0
2.0
1.0
IRON CONCENTRATION X10^4, PPM
BOSTON FOUL GROUND
PORTLAND HARBOR
BOSTON LIGHTSHIP
ROCKLAND DISPOSAL SITE
BRENTON REER
CORNFIELD SHOALS
ISLES OF SHOALS
NEW LONDON OUTER STA.
NEW LONDON DISPOSAL SITE
NEW HAVEN
WESTERN LONG ISLAND SOUND
CABLE AND ANCHOR REEF
* CORNFIELD SHOALS DISPOSAL SITE
* PISCATAQUA RIVER
* ROCKLAND HARBOR
INCREASING METAL CONCENTRATION, PPM ----→

FIG.-9

h. Heavy Metal Concentrations and Gonadal Development in Mytilus Edulis and Modiolus Modiolus.

(1) Deployment of Mussel Cages. Monitoring of heavy metals concentration in mussels placed in the vicinity of the dredge spoil disposal sites was initiated during 1978. During this period, monitoring platforms (figure 10) were deployed at the following northern and southern New England disposal areas:

(a) Northern New England - Modiolus Modiolus have been used as monitoring organisms.

Disposal Areas	Reference Areas	Date Deployed
Rockland	Drundard's Ledge	5-12-78
Portland	Bulward Shoals	5-14-78
To be established	Isles of Shoals	5-19-78
Boston Fould Ground	Halfway Rock	5-21-78
Boston Lightship	Halfway Rock	5-21-78

(b) Southern New England - Mytilus edulis have been employed as monitoring organisms.

Disposal Areas	Reference Areas	Date Deployed
Brenton Reef	Newport Outer Bridge	5-11-78
Cornfield Shoals	Off Cornfield Shoals Dump Site	1-16-78
New Haven Dump Site	Off New Haven Dump Site	4-10-78
Western Long Island Sound		4-10-78
Cable & Anchor Reef		4-10-78

(c) Collection Sources. For the Northern New England Stations, Modiolus modiolus were collected from the designated reference areas and deployed at their respective disposal areas. With the exception of Brenton Reef disposal area which was stocked with Mytilus edulis from a station north of the disposal site, Mytilus edulis from a single source, Latimer's Light, were distributed to the four other disposal areas and their respective reference areas in Long Island Sound. In addition, the level of heavy metals and gonadal conditions in Mytilus edulis from Latimer's Light are monitored regularly and serve as an overall reference for the Long Island Sound.

(2) Scheduling of Collections. Monitoring stations were to be visited on bimonthly intervals for the heavy metal and gonadal development investigations. Strict adherence to the exact sampling schedule, however, was difficult and at times nearly impossible to maintain because of unexpected logistic problems and weather conditions. Every effort, nevertheless, was made to conform to the bimonthly sampling regime. Occasionally we encountered occasional failures in retrieval of the monitoring platforms, but recent use of an improved version of the sonic release device promises to minimize future failures.

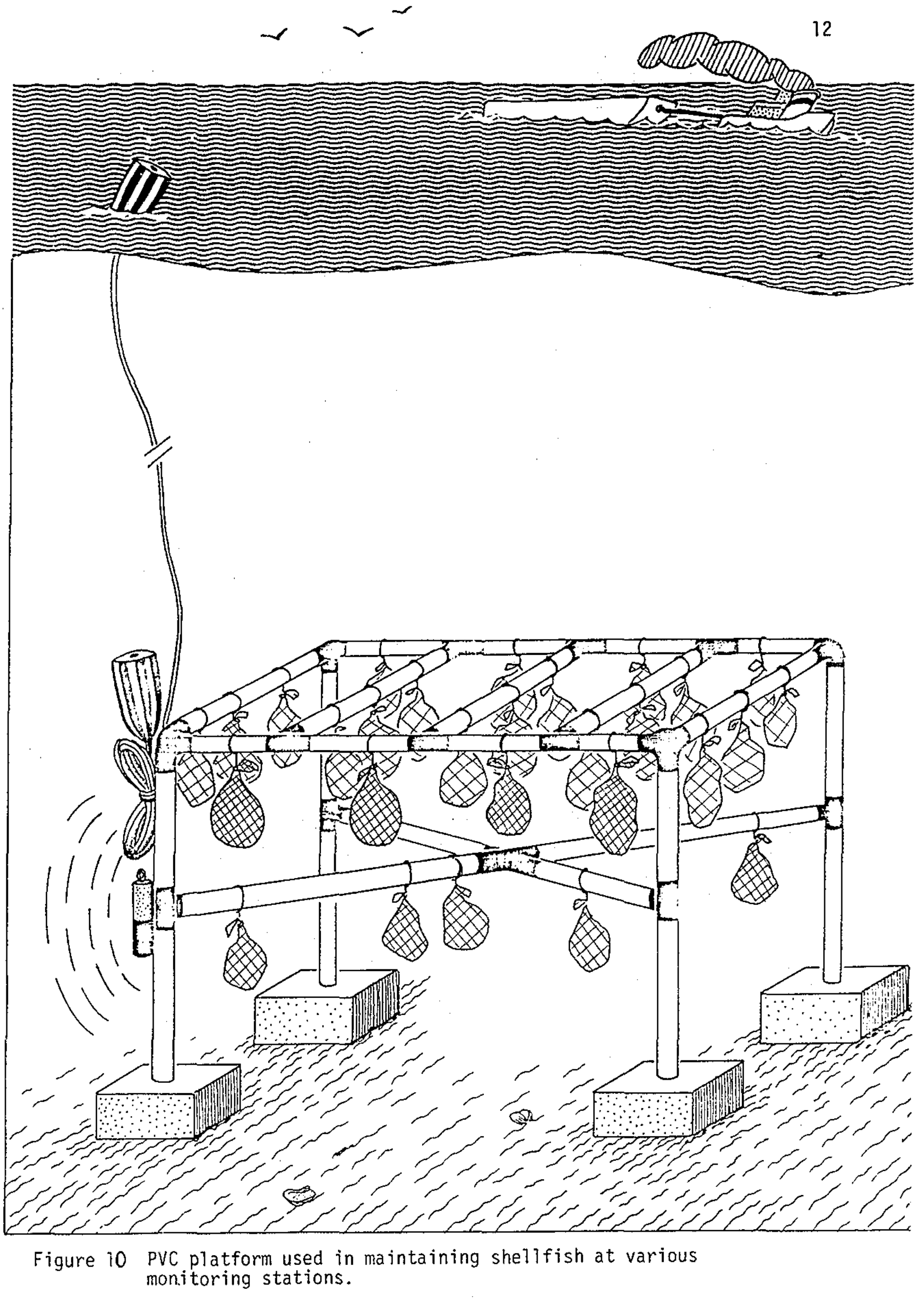


Figure 10 PVC platform used in maintaining shellfish at various monitoring stations.

(3) Field Procedure. Soft tissures of the whole shellfish were removed from the shells, homogenized and freeze-dried for heavy metal analysis. A portion of the freeze dried sample was digested in concentrated nitric acid at 50°C, diluted and analyzed by the established flame or cold vapor atomic absorption spectrophotometry technique with great care being taken during sample preparation to avoid contamination.

(4) Laboratory Procedure. The denuded shellfish were fixed either in a Bouin fixative or buffered formalin for gonadal development studies. A standard section was excised, dehydrated in an alcohol series and imbedded in paraffin. The paraffin block was sectioned to a thickness of 10nm using a microtome and mounted on a glass slide. This preparation was deparaffined in benzene and stained in Hexamtoxylin and Resin. The stained sections eventually were mounted in Permount thus ready to be examined microscopically.

(5) Data Pressutation. Heavy metal concentration data are presented for each disposal site area in a table of concentrations with associated standard deviations. The data also are presented as ratios of heavy metal content of the sample to the original baseline sample and plotted against time for each site in order to depict temporal variations in both the reference and disposal site samples. The upper and lower 95 percent confidence intervals for the baseline data are defined as $x \pm 2$. Those ratios falling within the prescribed 95 percent confidence intervals are not considered to be significantly different from the original baseline sample.

(6) Validation. Comparisons of heavy metal concentrations in Mytilus edulis collected from Latimer's Light and New Haven with those of comparable locations in southern New England as reported in the Mussel Watch Program, show good agreement between the two sets of data (table 7). The observed agreement becomes even more significant in reinforcing confidence in the results considering the variations implicit in sample preparation and analytical procedure employed by different laboratories.

(7) Relevancy. There is confidence that, although to date the amount of data obtained is still too small to realize its significance, the variance estimates derived from this study will prove extremely useful in the long term for interpretation of subsequent changes resulting from disposal activities. An example which illustrated the utility of the mussel monitoring is presented in figure 11. The data were derived from Mytilus edulis monitoring stations at the New London disposal site. During the predisposal period (March to August 1977), the ratios of Ni were all within the 95 percent confidence limits of the baseline data, which are delineated by a set of broken lines. Elevated ratios (up to 12 times the baseline data) coincided with periods of heightened disposal activities from September 1977 to February 1978.

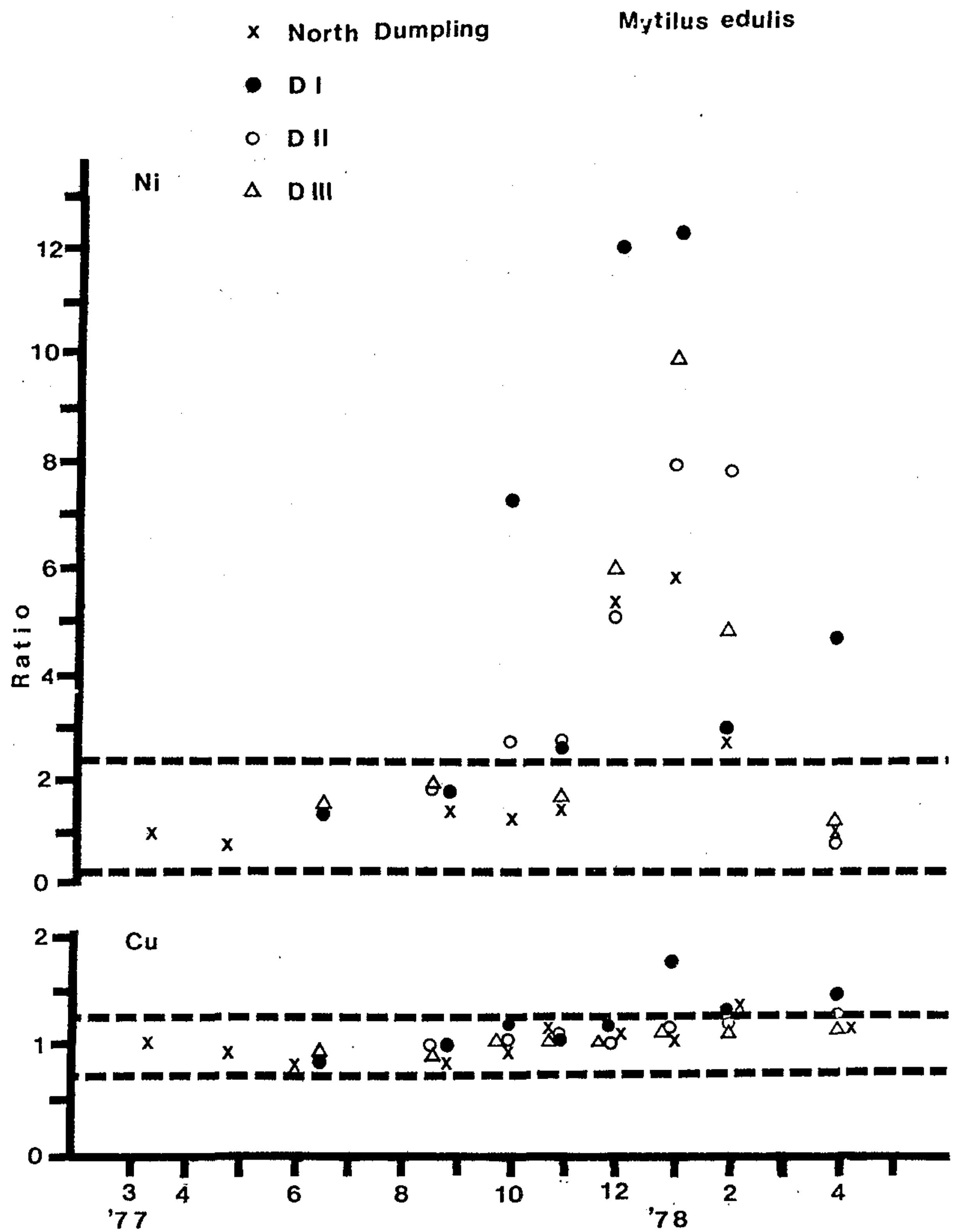


Figure 11 Temporal variation in the ratios of heavy metals in Mytilus edulis from New London monitoring sites: DI, DII and DIII, as well as North Dumpling, a reference site. Broken lines represent the 95% confidence limits of the baseline data.

As the disposal activity subsided in March 1978, the ratios (except DI) quickly returned to within the 95 percent confidence limits. The observed rise and fall of the ratios which correlated with the dumping activity also were apparent in mussels from the reference area (North Dumpling) which is located two miles east of the disposal area. The magnitude of the rise, however, is much less than at those stations located on or near the dumping area, attesting that Mytilus edulis is a sensitive environmental monitor. About 120 tissure sections are being prepared for microscopic examination of gonadal development. Data as yet are not available.

i. Benthic Macrofauna

(1) General. The benthic biota at eleven submarine disposal areas and five associated reference areas located from Rockland, Maine to Norwalk, Connecticut are being studied as a major portion of the DAMOS program. Disposal site boundaries are given in the DAMOS Progress Report for FY 77 presented to the New England Division, Corps of Engineers in January 1978. Some of the eleven disposal sites have received dredge spoil within the last year while others have been inactive for an extended period.

(2) Sample Collection. A total of 95 dredge samples of bottom sediment have been collected since the initiation of the DAMOS project. Forty-seven of these samples were collected between December 1977 and April 1978. A complete count and speciation of the benthic organisms containted in these samples was received from the subcontractor, the New England Aquarium, in mid-September 1978. These data have been collated and compiled and are presented here. An additional 48 sediment samples were collected from the 16 sampling stations between May and August 1978. A complete count and speciation of the contained organisms has been completed by the Aquarium. The sampling plan and sample analysis during the first year of this project as initially conceived were meant to be flexible and, to some degree, exploratory. It was anticipated also that upon completion of the analysis of the first year's collections of benthic macrofauna an updated research plan would be prepared consistent with the results of the preliminary data collections. This exploratory period has provided a great deal of useful information even though there has not yet been sufficient time to permit a complete analysis and interpretation of the data. It has furnished a valuable insight into numerous aspects of the benthic biology at the sampling sites, as will be seen.

(3) Sampling Processing and Speciation. Table 8 lists the 16 DAMOS sampling sites and the dates of sampling. Sampling operations in the Gulf of Maine were conducted from the R/V Edgerton, a 65-foot steel hulled "T" boat. Another "T" boat, the UCONN was chartered for use in Rhode Island Sound and Long Island Sound. All station locations were determined by use of a Decca Trisponder navigation system. Three repetitive anchor dredge samples were collected from each of the 16

sites on each of the dates listed. The anchor dredge was fitted with a heavy canvas collecting bag and collected a sample of surface sediment 20 cm in depth. It normally was dragged a distance of 200-400 m. along the bottom. The bag when full holds approximately 0.08 meter^3 of material. The contents of the dredge were emptied into a large polyethylene tub and subsamples of 15 liters of sediment were removed. The subsamples then were sieved through two-tiered sieving screens nested in a wooden table specially constructed to accomplish this task. The sieve material used in the top screen (commercially known as "Vexar") is made from solid vinyl with a .83 cm^2 mesh opening. The lower sieve is made from ordinary fiberglass insect screening with a mesh opening of 1 mm^2. The organisms after sieving, were removed from the screens and preserved in a 10 percent seawater-formaldehyde solution for subsequent counting and speciation in the laboratory. All identifications and counts of benthic organisms were made by the research staff at the New England Aquarium. Two additional sediment samples were collected from each dredge; one for a sediment grain size analysis and the other for an analysis of the sediment heavy metal content.

(4) <u>Statistical Procedures</u>. Species diversities (a single value widely used by ecologists to indicate the stability of a benthic community) given in this report, were calculated using the Shannon and Weaver (1936) index: H^1 = Piln pi where pi is the proportion of individuals in the ith species. Diversity (H^1) takes into account both the number or "richness" of species (S) and equitability ($J^1 = H^1/H^1$ max = H^1/ln S) (Peilou, 1975). Equitability provides a measure of the evenness of the distribution of individuals among species (Patten, 1962). Another statistic reported here, the coefficient of dispersion (CD) (variance: mean ratio) provides an indication of the distribution of a species on the bottom. A CD equal to 1 suggests random distribution; greater than 1 or less than 1 indicate that the distribution is clumped or even, respectively (Greig-Smith, 1964). These spatial distribution patterns can have an important bearing on the types of analytical methods used in data treatment as well as the interpretation of the results of the analysis.

(5) <u>Confidence Limits</u>. All confidence limits cited throughout this section of the report were calculated at the 95 percent level as the product of the standard error of the mean and the appropriate value from a two-tailed "t" table (Snedecor, 1956, pp. 47-48). It is assumed wherever these confidence limits overlap that no significant difference exists between their respective means.

All collected organisms wherever possible were identified to species. Colonial forms (e.g. Bryozoa, some Cnidaria and some Porifera) in the counts of these organisms were marked with a "+" if present and each separate colony was counted as a single individual.

Each of the 16 sampling stations has been treated as a unique, separate entity grouped according to three general regions, namely five stations in the Gulf of Maine, two stations in the Rhode Island Bight and nine stations in Long Island Sound.

(6) Discussion of Species List, Gulf of Maine. Table 9 provides a master listing of all the species collected from the five stations located in the Gulf of Maine, their frequency of occurrence, and total number of individuals in the 15 dredge samples collected during the winter of 1977-78. Salient features of this listing are presented in table 10. They show that in the total number of 3032 individuals there were 15 phyla and 134 species represented. Eleven species predominated, comprising nearly 70 percent of the total number of individuals. This predominant species list, as with comparable listings for stations in the Rhode Island Bight and Long Island Sound, omits species which contributed less than about 2 percent of the total number of individuals of the particular compilation. Only two phyla, the molluscs and the annelids predominate at these Gulf of Maine stations. The distribution of phyla, species and number of individuals at each of the five sites is presented in table 11. The largest number of individuals was collected from the Rockland, Maine dump site; fewest numbers were found at the Boston Foul Ground site. The distribution of predominant species as well as several pertinent statistics, is presented for each individual sampling site in the Gulf of Maine in table 12A-12E. The format of these tables of numeric density data is essentially that recommended for presentation of benthic data by the U.S. Environmental Protection Agency. There are several general statements that can be made on the basis of the data contained in these tables.

(a) Sample to sample variability is high. This is evident from a perusal of the numbers of individuals retrieved from one dredge sample to the next. The standard deviations help to quantify this variability. The standard deviations exceed their means in many instances.

(b) The coefficients of dispersion with rare exceptions indicate a spatial distribution pattern which is highly clumped at all stations.

(c) Generally, only a small percentage of the total number of species predominate a given station. This small percentage of species often accounts for 80 percent or more of the total population collected.

(d) Diversity (H^1) values close to 3, have been reported as typical of the shallow shelf and unpolluted estuaries; values between 1 and 2 are found in brackish areas and polluted areas. The mean diversity values calculated for the Gulf of Maine stations are highest at Portland (3.05) and gradually decrease to 2.36 as one travels to the Isle of Shoals, the Boston Foul Ground and the Boston Lightship. The extremely low diversity value (0.034) for the Rockland, Maine dump site which is located in the seemingly pristine environment of Penobscot Bay is difficult to explain.

(e) The values for equitability or evenness of distribution of individuals among species are essentially the same at Portland, Isle of

Shoals, Boston Foul Ground and Boston Lightship stations, but are very low at the Rockland dump site.

(7) Gulf of Maine. The data summary in table 13 compares the five stations in the Gulf of Maine in terms of the mean numbers of species and mean numbers of individuals collected from each site. All of the 95 percent confidence limits overlap and one is forced to conclude that there are no significant differences between the mean number of species or between the mean number of individuals at any of these stations. This finding comes as no surprise and is due, at least in part, to the unforgiving nature of the statistical techniques employed, especially when dealing with small sample size and high sample variability. Other, more sensitive techniques (e.g. correspondence analysis, the Bray-Curtis similarity indexes and perhaps linear discriminant analysis) are being considered for possible application to the entire DAMOS benthic macrofauna data set to more clearly define community characteristics at each sampling site.

(8) Rhode Island Sound. Table 14 presents the list of species, frequency of occurrence and number of individuals collected from the Brenton Reef disposal and reference sites. These data are summarized in table 15 which shows that the total number of phyla collected at the two sites was nine, comprising 83 species and 10473 individual benthic organisms. An extremely dense population of the amphipod, Ampelisca agassizi collected from the Brenton Reef reference site explains the high count of individuals. Members of this species accounted for 8080 individuals or slightly more than 77 percent of all individuals collected at the two sites. This one species comprised such an overwhelming majority of the total that two predominant species lists were prepared; one with A agassizi included and the other without this species. It was felt that this was necessary to allow a more realistic compilation of important species at these sites for comparison with the Gulf of Maine and Long Island Sound stations.

A small percentage of the total number of species, as was with the Gulf of Maine stations, accounts for a high (92 percent) cumulative percentage of the total number of individuals. Perhaps the most striking difference between the predominant species at these sites and those in the Gulf of Maine is the absence of molluscs and the increased importance of arthropods. Table 16 presents the distribution of the number of phyla, species and individuals at each of the two sites sampled in Rhode Island Sound. Numeric density data for each station are shown in tables 17A and 17B. Many of the general statements made about the stations in the Gulf of Maine apply as well to these sites, namely high sample to sample variability, a clumped spatial distribution and a small percentage of the total number of species accounting for a large percentage of the total number of individuals (at the reference site). The values for diversity are somewhat lower than most of those calculated for the Gulf of Maine indicating a somewhat less stable environment at the Brenton Reef sites. The presence of such large a number of Ampelisca agassizi, a species considered sensitive to pollution, would argue that some degree of instability rather than pollution is the probable reason for a lower value of diversity. The mean value for species evenness (j^1) is somewhat higher at the Brenton Reef dump site than for most of the more northern stations and is notable higher than that calculated for the Brenton Reef reference station

Examination of the 95 percent confidence intervals around the means for species and individuals at the two Rhode Island Sound stations, presented in table 18, shows that both the number of species and number of individuals collected from the reference station was significantly greater than from the disposal site.

(9) Long Island Sound. The master species list, the frequency of occurrence and number of individuals in the 26 dredge samples, collected from the 9 stations in Long Island Sound, are shown in table 19. A summary of the more important aspects of this table is presented in table 20. Sample collections from the Sound produced 2190 individual specimens of the benthos consisting of 140 species and 11 phyla. Arthropods and annelids were among the most predominant species in the collections. The inclusion of the mollusc, Mytilus edulis (the edible mussel) in the list of predominant species is somewhat misleading since it was found in large numbers at only one station, the New London reference site. Rarely has it been collected from stations west of the Cornfield Shoals area. A breakdown of the distribution of the number of phyla, species and individuals collected from the nine sampling sites in Long Island Sound is presented in table 21.

The largest numbers of individuals were collected at the sampling site referred to as the New London dump site. These samples were not taken directly from the disposal pile itself, but rather from a station located a few hundred meters northeast of the edge of the pile. The lowest numbers of individuals found were at the Cornfield Shoal dump site. The numbers of species found at the two New London sampling sites far exceeded the number of species found at any other Long Island Sound station. Tables 22A-22I present numeric density data for each of the nine Long Island Sound sampling sites. Sample to sample variability for all stations examined was very high and, for the most part, a relatively small number of species made up a large percentage of the total individuals collected. The mean value for species diversity was highest (2.62) at the New London reference station, and lowest at the Cornfield Shoal dump site, because of the high-energy physical environment at Cornfield Shoals. Strong currents in this area and a concommitant sandy bottom probably prevent the establishment of many of the benthic species indigenous to sediments in the immediate vicinity. Values for species evenness do not seem to differ from one site to the next.

It should be noted that the predominant species list for the New London dump site (table 22A) has been corrected for 635 specimens of

Ampelisca vadorum. The logic is the same as that for the Brenton Reef reference site. A few other tables (e.g. 17, 22E, and 22F) also have been corrected for various species. The corrections in these instances are very small and of little consequence to the overall picture. The species involved are organisms such as nematodes and copepods which ordinarily are considered meiofauna or planktonic. The organisms were retained fortuitously in the samples. They will be excluded in future studies from the counts of the benthic macrofauna.

(10) Discussion of Species List, Long Island Sound. The mean numbers of species and individuals of the nine stations in Long Island Sound are compared in table 23. If the Cornfield Shoal samples are temporarily excluded from consideration (the rationale being that it is a very high-energy environment and thus quite different from all the other sites) there is a pronounced decrease in numbers of species and individuals as one progresses westward down the Sound from the New London stations. A strict interpretation, in some, but not all instances, of the 95 percent confidence intervals for species means confirms this observation. One is forced to conclude when like criteria are applied to the 95 percent confidence intervals around mean numbers of individuals that no significant differences exist over the entire transect. It is obvious that this is the consequence of high sample to sample variability, small sample size, and general insensitivity of this statistical operation.

An opportunity to compare the results of grab samples with dredge samples was afforded by collections made at the New London reference site in March 1978. This comparison is made in table 24. Five Smith-McIntyre grab samples were collected from the New London reference site during a separate study of the New London disposal site by the same personnel using the same navigation system,.and sameship that were used to obtain three dredge samples from the site. The two sets of samples were identified by the same staff members of the New England Aquarium. The top half of table 24 shows the results of counts of species and individuals for grab samples collected in March 1977 and 1978 and for comparable counts obtained from dredge samples collected in March 1978. The counts for all samples are very similar and, when compared with other series of samples, exhibit a fairly low degree of variability. The degree of similarity is confirmed by the 95 percent confidence intervals which in this case are quite narrow and lead to the conclusion that no significant difference exists betwen either the mean number of species or the mean number of individuals sampled by the two collecting methods. Disregarding the 95 percent confidence intervals for the moment, however, it can be noted that the mean number of individuals collected per dredge sample is only about one-half of the mean number collected in the grab samples. The bottom half of table 24 examines the relative effectiveness of the two collecting methods by a probably oversimplified approach. Thirty-six of the total number of species collected in March 1978 were common to each set of samples.

The total number collected by both methods was 107. Sixty-four percent of this total were found in the grab samples and 70 percent in the dredge samples. In the case of the comparison of the number of individuals collected by each method, the number of dredge samples was artificially increased to five by adding a number equal to twice the mean (167 x 2 = 334) collected in the three dredge samples, bringing the total number of individuals to what might have been expected had five dredge samples actually been collected. Calculation of the resulting percentages shows that the dredge samples contain about 50 percent fewer numbers of individuals than were collected by the grab samples.

(11) <u>Conclusion</u>. The relationships between mean number of individuals (N), mean number of species (S) and mean values for diversity (H^1) at all of the DAMOS stations sampled during the winter-spring collection period are shown on figure 12. The curves for the three variables in most instances follow similar contours. There was a notable exception at the Brenton Reef reference station. It will be interesting to compare this graph with one prepared from the DAMOS summer collections data.

A summary of the conclusions resulting from analysis of the benthic data follows:

(a) Sample to sample variability is high at all stations. In many cases standard deviations exceed their means.

(b) Station to station variability is also high.

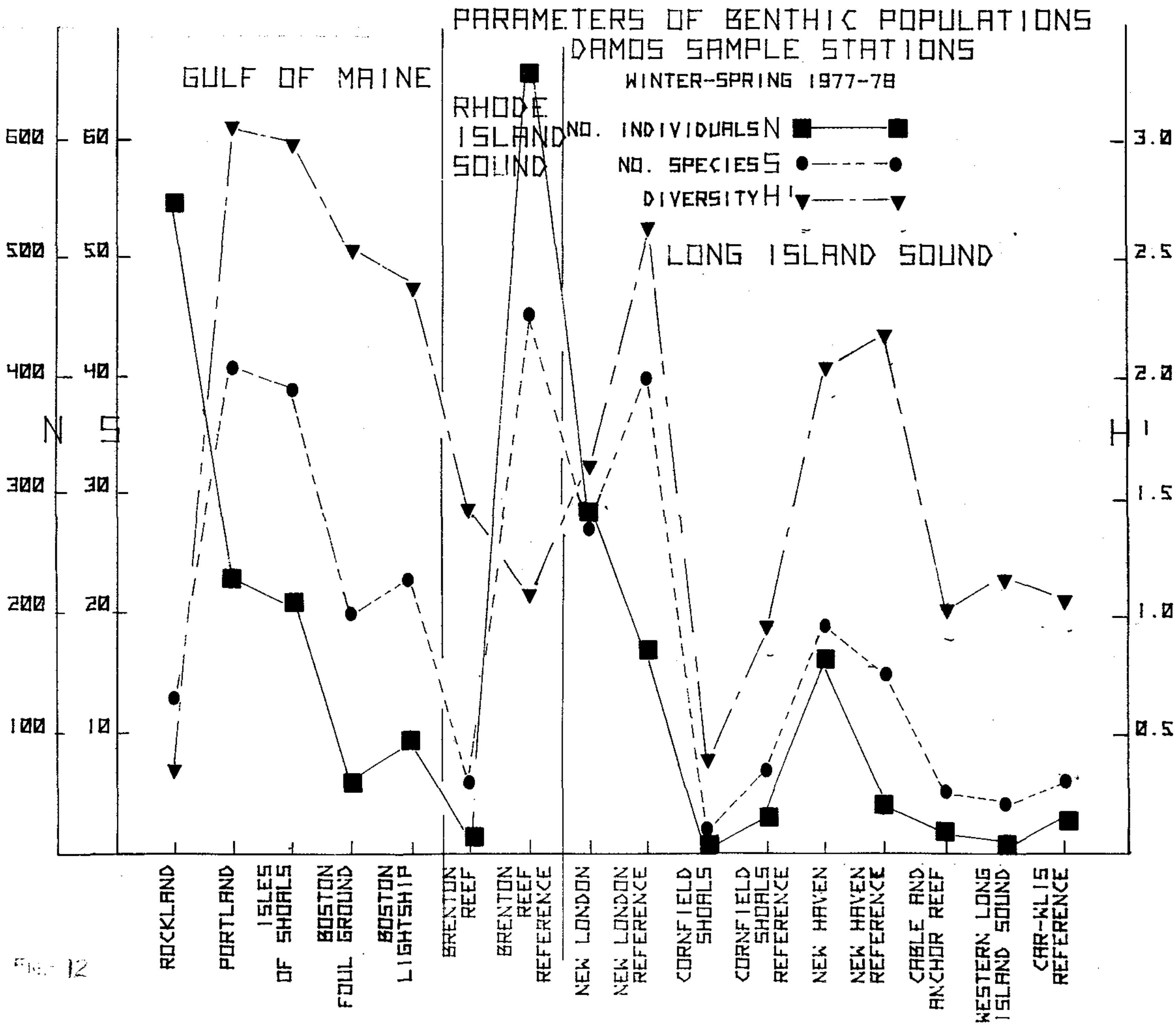
(c) With rare exceptions coefficients of dispersion indicate a spatial distribution pattern which is highly clumped.

(d) At nearly all stations, a small percentage of the total number of species predominate and these predominant species commonly comprise 80 percent or more of the total number of individuals collected from a given station.

(e) Values for species diversity (H^1) are relatively high at all but one station in the Gulf of Maine, ranging from 2.4 to 3.0. Diversities at Rhode Island Sound and Long Island Sound stations are lower and range from below 1.0 to 2.6.

(f) Generally speaking, the number of species and the number of individuals making up the macrofauna at the sampling stations in the Gulf of Maine, decrease on a transect from Portland, Maine to Boston, Massachusetts.

(g) In Long Island Sound, there is a general decrease in number of species and number of individuals on a transect from the New London



PARAMETERS OF BENTHIC POPULATIONS
DAMOS SAMPLE STATIONS
WINTER-SPRING 1977-78
GULF OF MAINE
RHODE ISLAND SOUND
LONG ISLAND SOUND
NO. INDIVIDUALS N
NO. SPECIES S
DIVERSITY H'
N
S
H'
600
500
400
300
200
100
60
50
40
30
20
10
3.0
2.5
2.0
1.5
1.0
0.5
ROCKLAND
PORTLAND
ISLES OF SHOALS
BOSTON FOUL GROUND
BOSTON LIGHTSHIP
BRENTON REEF
BRENTON REEF REFERENCE
NEW LONDON
NEW LONDON REFERENCE
CORNFIELD SHOALS
CORNFIELD SHOALS REFERENCE
NEW HAVEN
NEW HAVEN REFERENCE
CABLE AND ANCHOR REEF
WESTERN LONG ISLAND SOUND
CAR-KLIS REFERENCE

Fig. 12

disposal site west to sites located off Norwalk, Connecticut.

(h) Two phyla, the molluscs and annelids predominate at stations located in the Gulf of Maine; at the two stations in the Rhode Island Sound arthropods and annelids make up the largest percentage of the benthos, and the Long Island Sound fauna is dominated by arthropods, molluscs and annelids.

(i) Though inconclusive, a comparison of the relative efficiency of the Smith-McIntyre grab sampler with the anchor dredge, suggests that they both sample about the same number of species though the species captured by the respective samplers may be quite different. This same comparison suggests that the dredge collects only about one-half the number of individuals as does the grab.

(j) A more detailed interpretation of these samples has suffered from the application of generally insensitive analytical techniques and a lack of information on precise sediment characteristics. It is anticipated that as the research continues, analytical tests will be refined and sediment grain size information will become available.

(12) Recommendations. Recommendations to be implemented for future benthic studies include:

(a) Samples at DAMOS stations should be taken with a Smith-McIntyre sampler taking at least four samples at each station.

(b) Sample analysis should concentrate on the identification of only predominant species which would exclude consideration of all Protozoa, Nematoda, Platyhelminthes, Rynchocoela, Priapulida, Sipunculida, Chordata Bryozoa, and Porifera. These organisms should be counted only when found in uncommon abundance. Counts of benthic macrofauna would thus be primarily limited to arthropods, annelids, mulluscs, cnidarians and echinoderms and may result in lower per sample cost.

3. COMMERCIAL FISHERIES

a. Introduction. A practical requirement to the monitoring program is a study of the effect of disposal on commercial fisheries. In many cases the disposal operation and fishing interests are sharing the same piece of ocean; sometimes in conflict and sometimes to the benefit of both. The purpose of this portion of the DAMOS program is to examine the fisheries existing in the near shore waters of New England and to open lines of communication with fishing interests in order to minimize the adverse effects and maximize the advantages of disposal relative to the fishing industry.

b. Acquisition of Data. Data relative to the commercial fisheries are obtained either by direct interviews with fishermen and fishing interest groups, or by research into information available from the National Marine Fisheries Service and other government and state organizations. Actual fishery data from a given site are generally obtained by interviews with fishermen and presented in the appendices accompanying this report. Site specific information, however, is generally not available for feeding, spawning, migration, density, and catch pattern of commercially important species. The scientific literature, and federal and state catch data, therefore, are being examined for relevant information. Some problems which have special relevance for this project are the location of herring spawning grounds, patterns in fish trap catch data, location of potentially harvestable ocean quahog stocks, and potential for recovery of the northern shrimp fishing.

c. Gulf of Maine. The key species in the Gulf of Maine and Southern New England are different enough to make it convenient to present data from each area separately. A summary of data on the biology of commercially important finfish in the Gulf of Maine is given in table 25. This includes information on spawning patterns illustrated in figures 13A-13I. The only key species with a restricted spawning ground near potential disposal sites is the Atlantic herring. Herring lay their eggs in mats on clean sand or gravel in areas of high current flow along much of the southern Maine coast (figure 13-E). Although eggs on the bottom could be buried or silted in by disposal of dredge spoil, it is unlikely inasmuch as the requirement for containment sites would indicate disposal in silty areas with low currents. The only other key species caught in the area having demersal eggs is the winter flounder which spawns in bays and estuaries, usually in less than 30 feet of water.

The remaining commercial species in this area release floating eggs. Whiting spawn along the shole coast. Cod, polluck, and haddock have spawning grounds south of Maine. Gray sole, dab, and cusk which are nonmigratory, spawn throughout their range.

Catch records for Cumberland County, Maine (Appendix figures 14A-14J) show that many of the fisheries are undergoing changes which could confuse an interpretation of the effect of dredge spoil disposal. Haddock, pollock, dab, and winter flounder catches increased from 1973-1976. Whiting decreased during that period and cod and cusk catches were stable.

Monthly catch records illustrate seasonal changes which would further confound interpretation of spoil effects. Since fish are caught in all seasons, there is no reason to specify a period of minimum potential effect.

d. Southern New England. The effort in southern New England relative to fisheries has been centered chiefly on the lobster industry since it is the dominant fishery in the area. Rhode Island and Connecticut lobster logbook records will be used in the analysis of catches

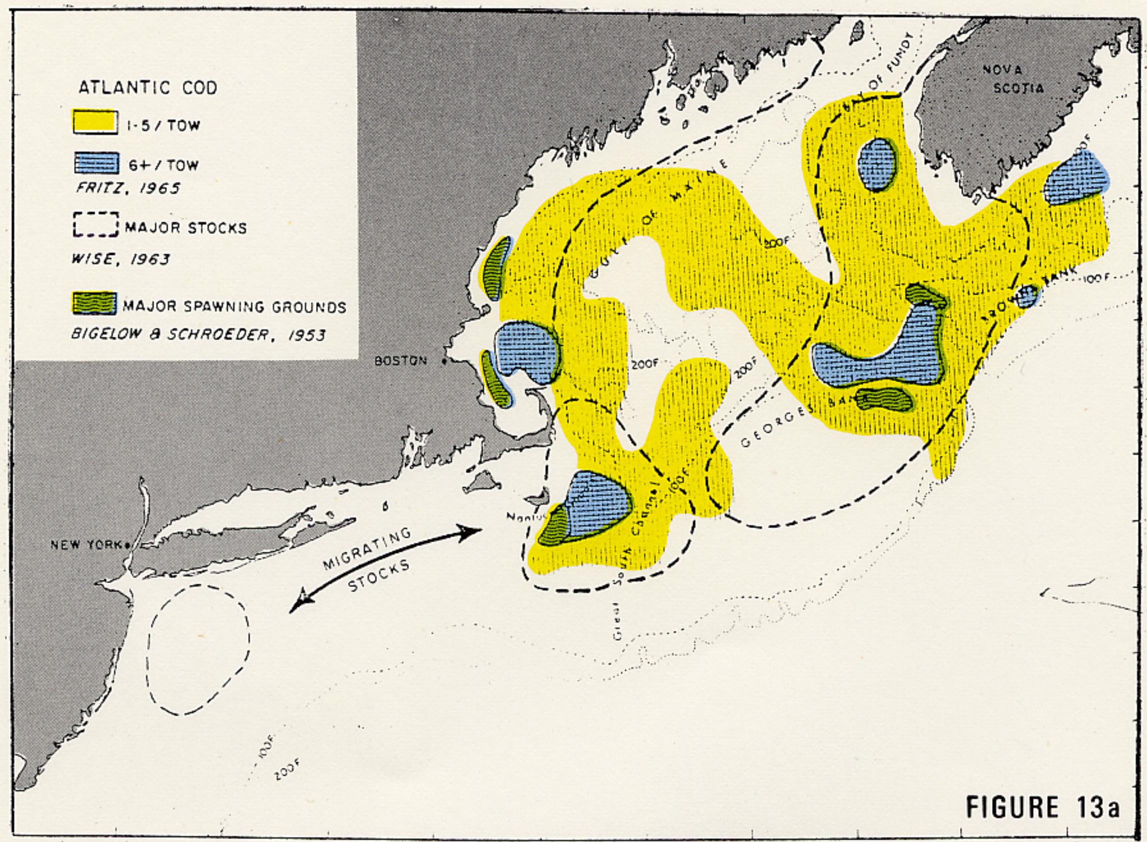


FIGURE 13a

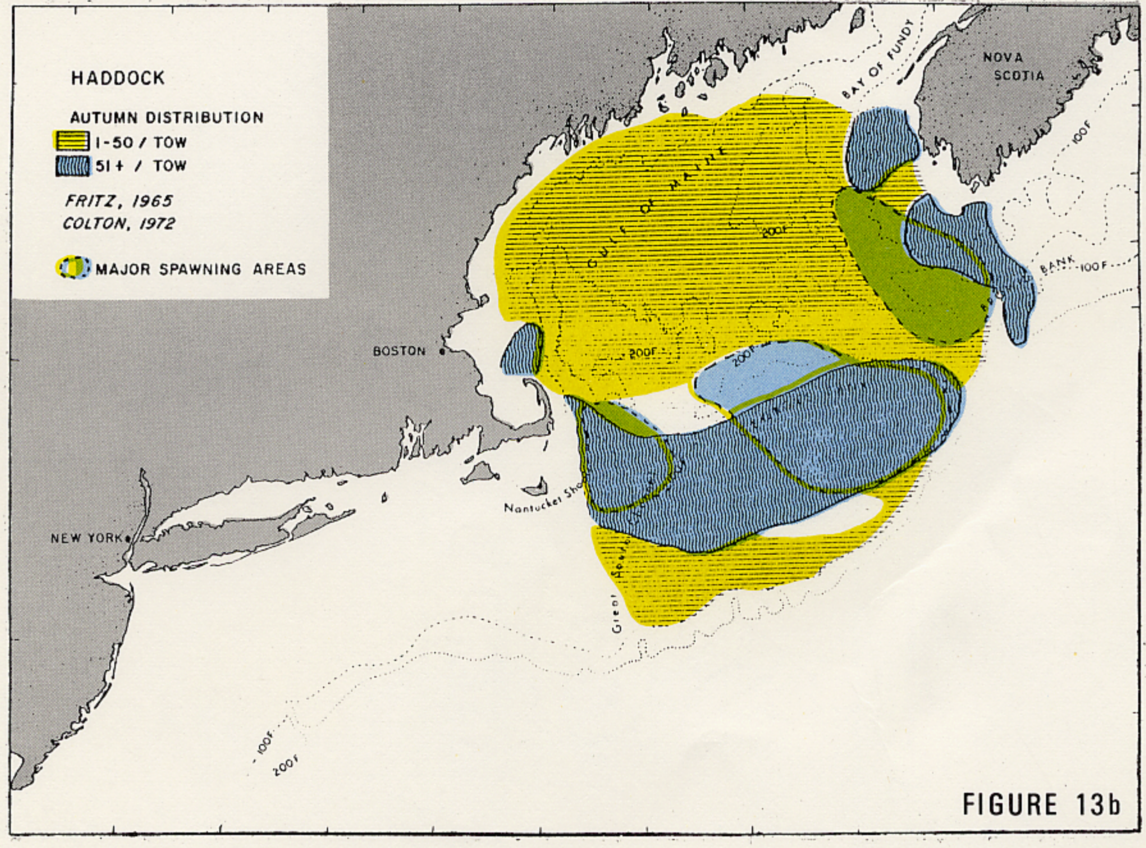


FIGURE 13b

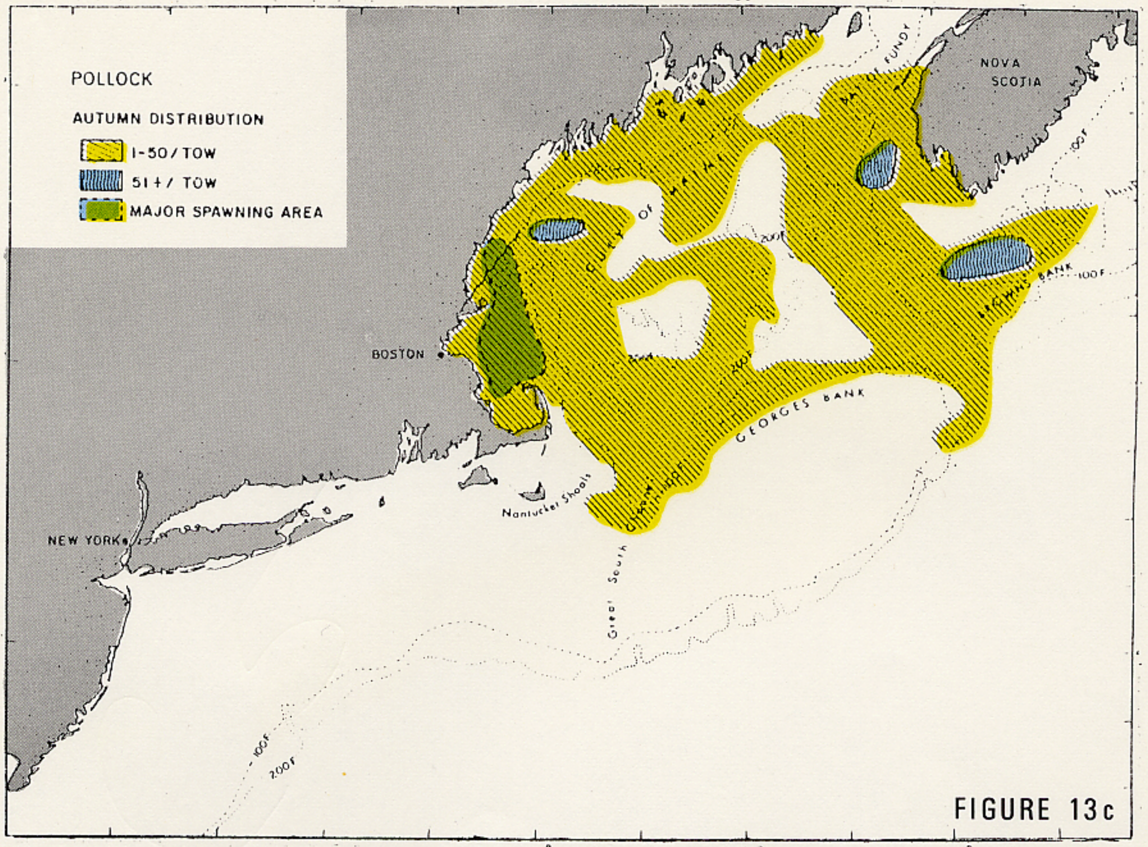


FIGURE 13c

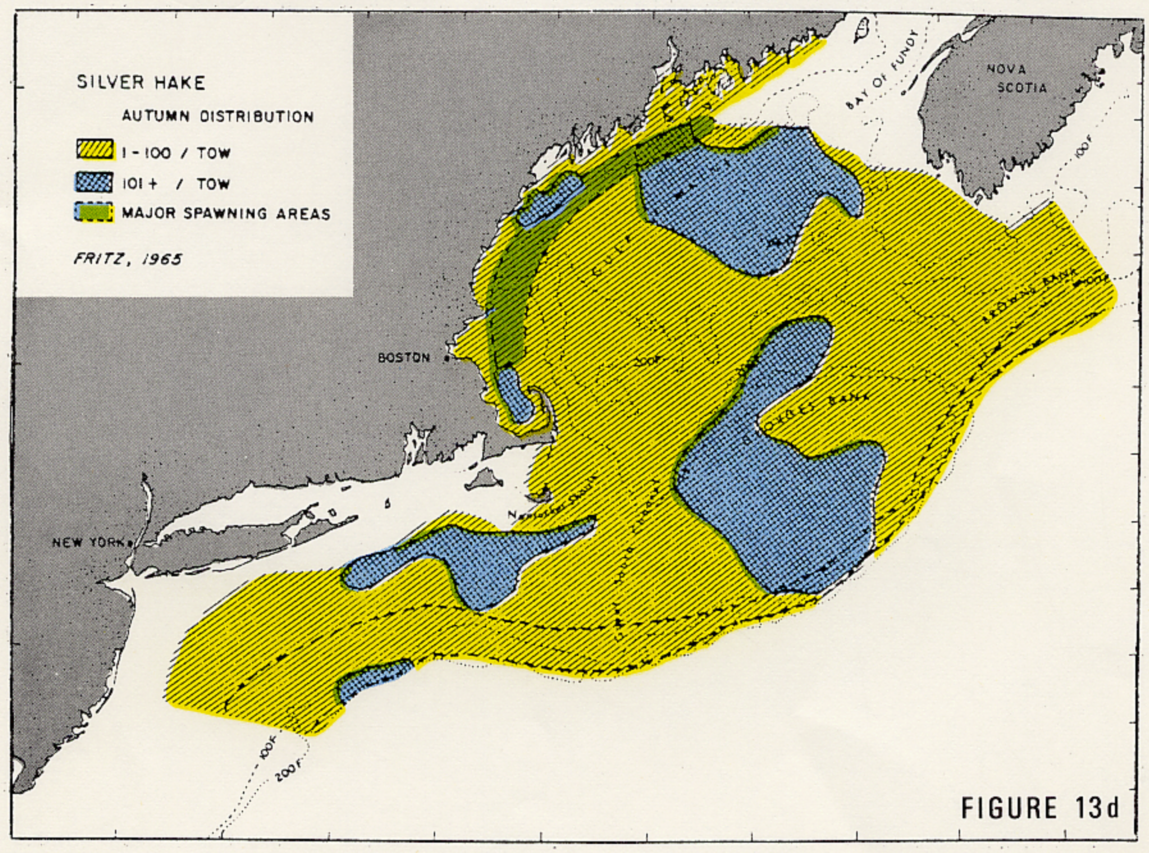


FIGURE 13d

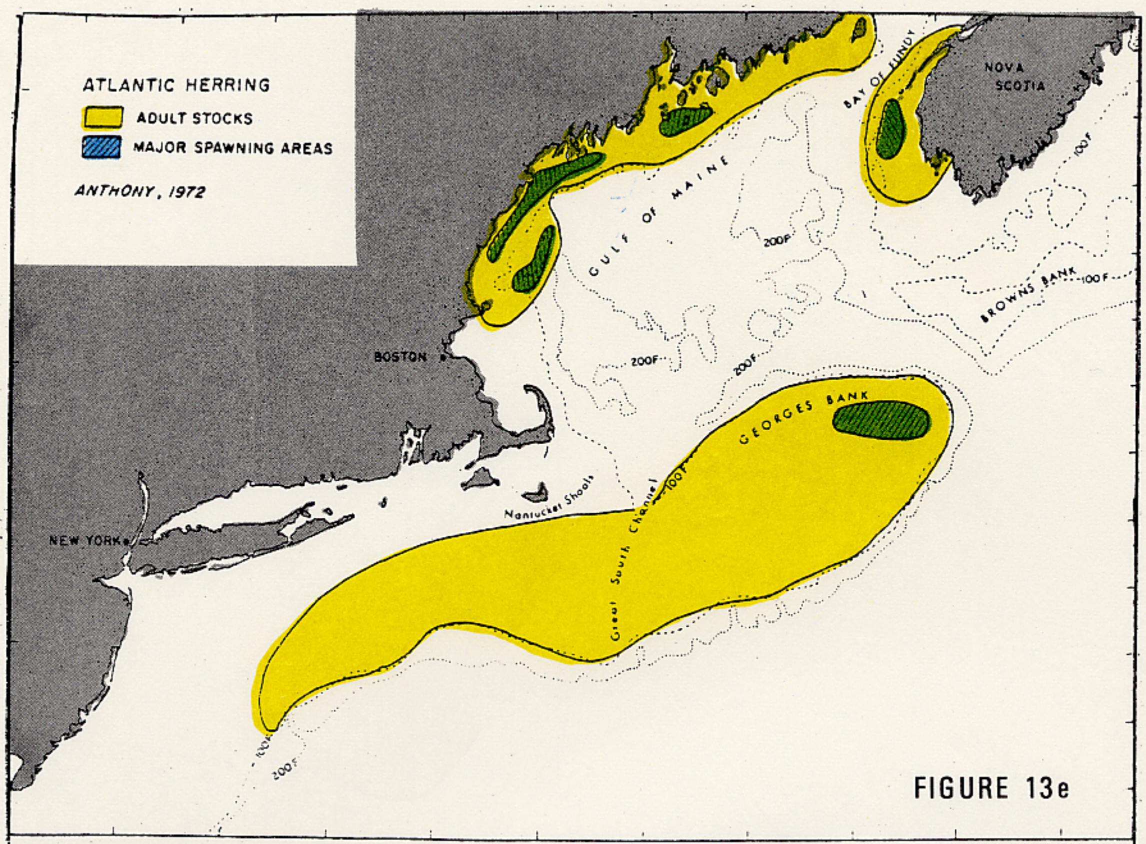


FIGURE 13e

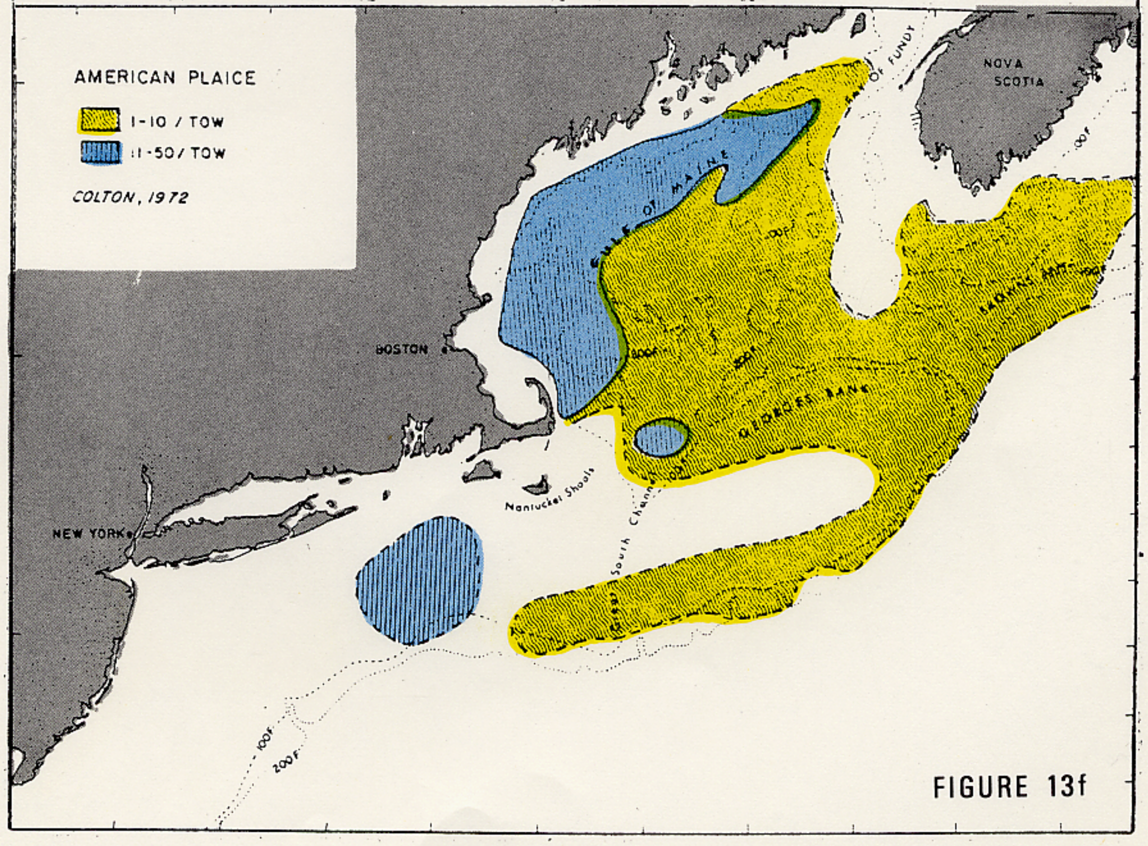


FIGURE 13f

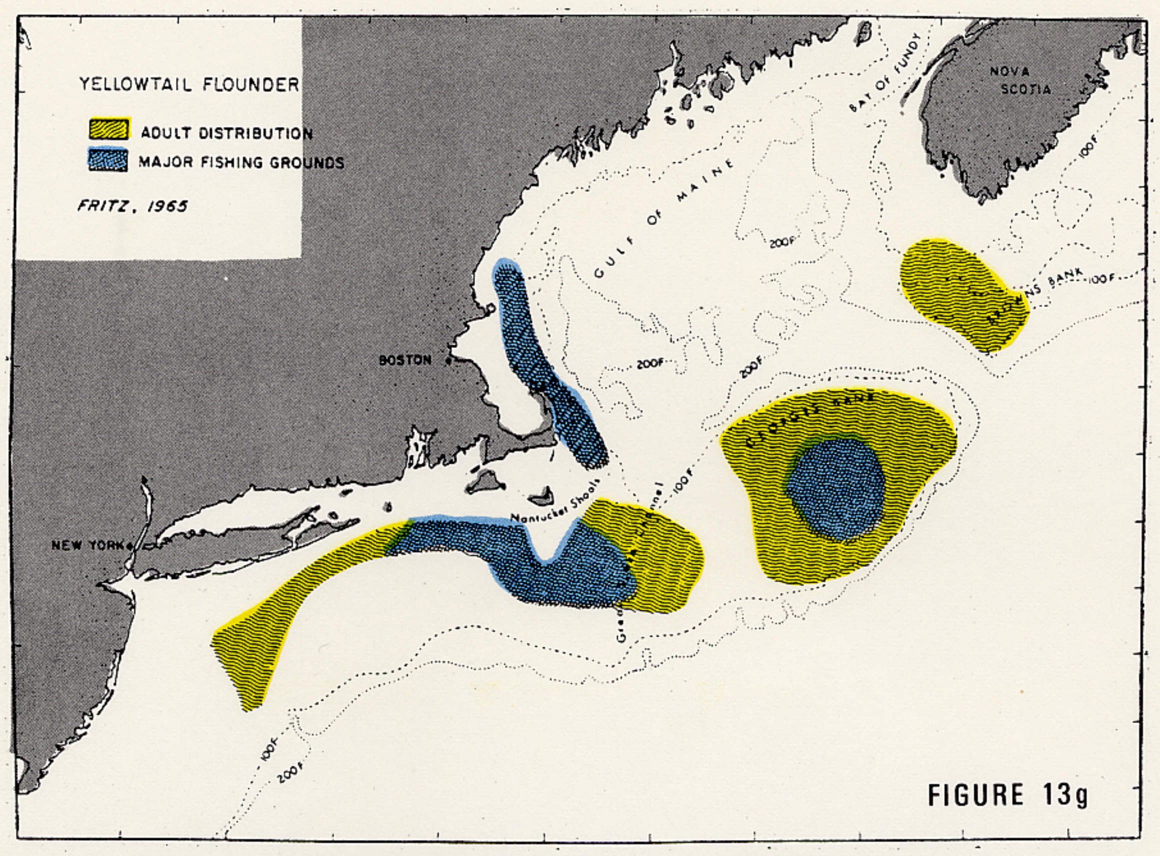


FIGURE 13g

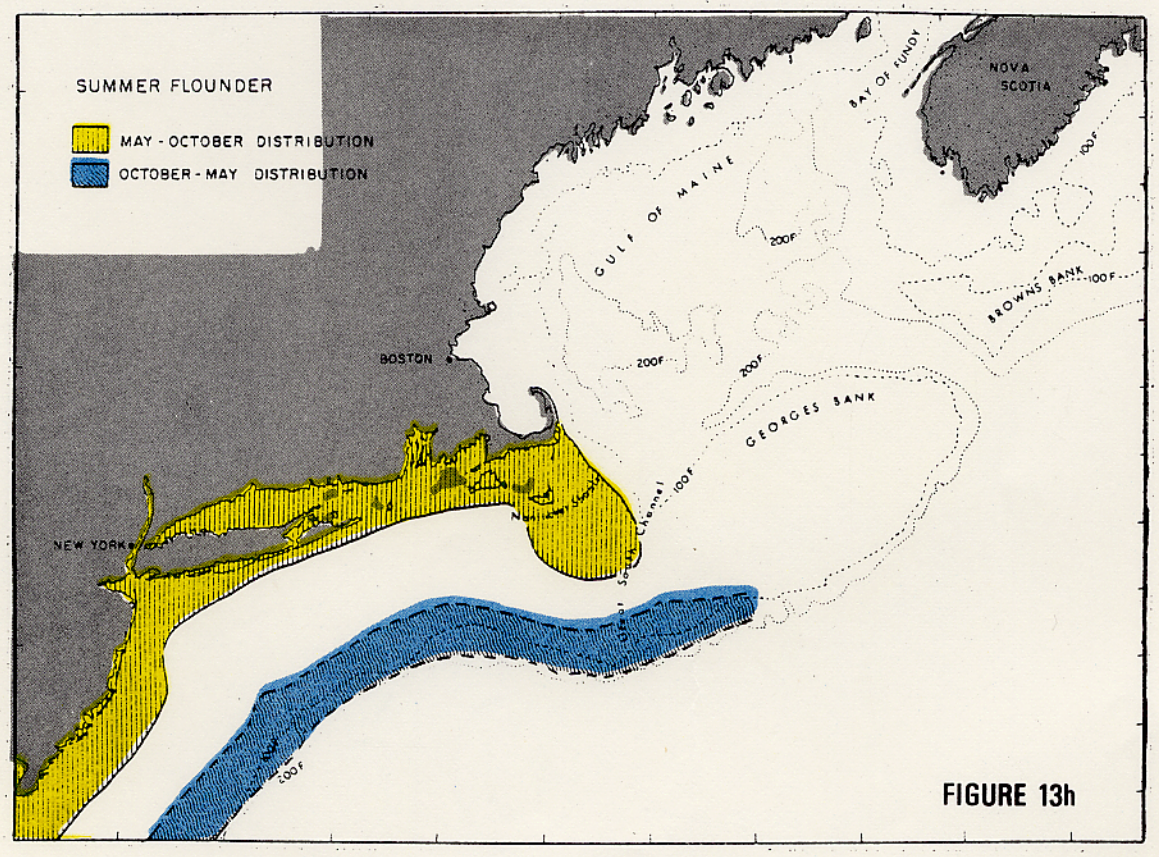


FIGURE 13h

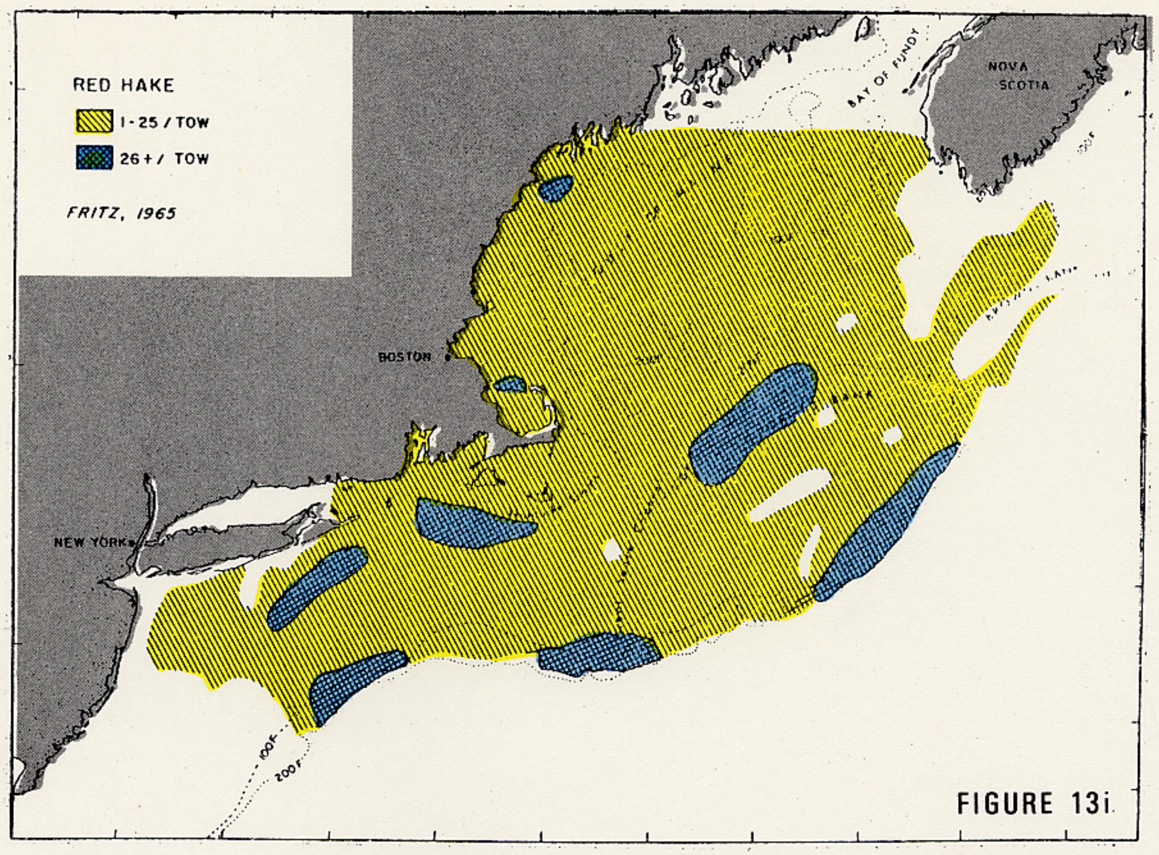

RED HAKE
1-25 / TOW
26+ / TOW
FRITZ, 1965
BOSTON
NEW YORK
BAY OF FUNDY
NOVA SCOTIA
100F
200F

FIGURE 13i

in Southern New England. Rhode Island initiated a reporting system in 1978 which will identify areas fished and information necessary to calculate catch per effort. Representatives from the Rhode Island Department of Natural Resources have stated that these data will be useful in protecting good fishing frounds from being used as dump sites (National Fisherman, November 1977). While these data will be valuable in assessing fishing pressure on the stock and seasonal movements of the fishery, it is not site-specific enough to be able to recognize the effects of spoil disposal.

Combined New York and Connecticut catch data are available for Long Island Sound from 1975-1977. During this period, landings and dollar value increased slightly and catch per effort remained stable. In 1977, 747,000 pounds were landed worth $1,454,000. For reporting of catch data, the Sound is broken up into east, west and central regions in each state (figure 15). Data from 1977 (table 26) show the relative importance of western Connecticut and eastern New York catches (41.8 and 21.8 percent of the total).

Data on location of landing give some additional information on catch areas, especially in the parts of the Sound where fishing areas lie offshore of landing ports. The area near the mouth of the Connecticut River appears to have a low catch in relation to its area based on landing records.

e. <u>Field Operations</u>. Most of the data discussed in this report were obtained between December 1977 and September 1978. During this period, two major cruises were made to each disposal site and several shorter trips were taken to accomplish maintenance and sampling of current meters and mussel cages. Most surveying was accomplished aboard the R/V EDGERTON and R/V UCONN with assistance from the R/V EAST PASSAGE, a 26-foot aluminum craft used primarily for diving and maintenance of mooring systems.

A summary of the data obtained and the time frame for each acquisition is presented in figures 16A-16B. Actual locations of samples are given in tables 27A-27K. Summary information is given in this section. Site specific data are presented in Appendices to the report. In this manner sections of the report can be used as complete entities for presentations relative to given sites or at public hearings.

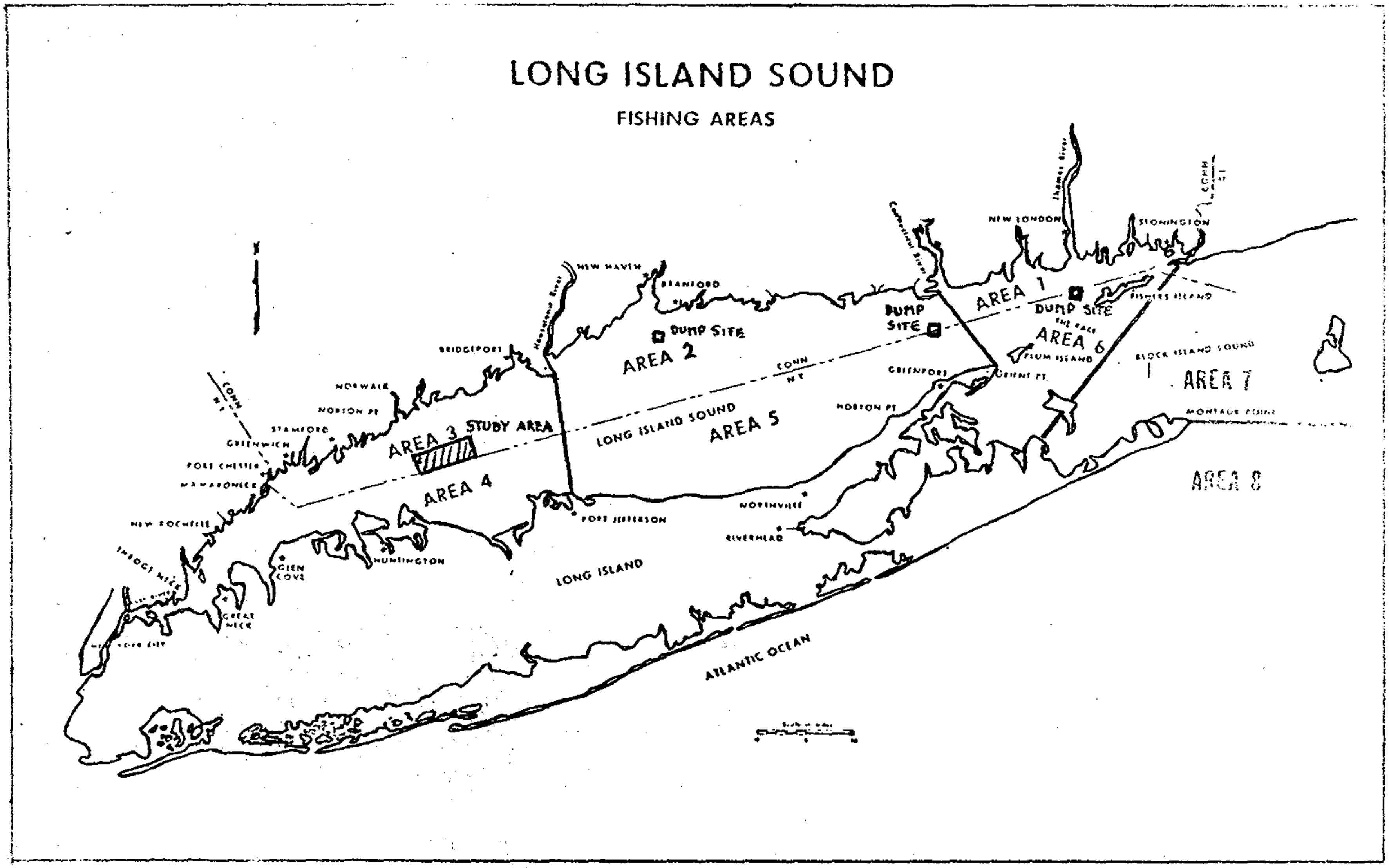

LONG ISLAND SOUND
FISHING AREAS
AREA 1
AREA 2
AREA 3
STUDY AREA
AREA 4
AREA 5
AREA 6
AREA 7
AREA 8
DUMP SITE
DUMP SITE
DUMP SITE
NEW LONDON
STONINGTON
NEW HAVEN
BRANFORD
BRIDGEPORT
NORWALK
NORTON PT
STAMFORD
GREENWICH
PORT CHESTER
MAMARONECK
NEW ROCHELLE
GREENPORT
ORIENT PT.
PLUM ISLAND
FISHERS ISLAND
BLOCK ISLAND SOUND
MONTAUK POINT
CONN
N Y
LONG ISLAND SOUND
NORTON PT
NORTHVILLE
RIVERHEAD
PORT JEFFERSON
HUNTINGTON
GLEN COVE
GREAT NECK
LONG ISLAND
ATLANTIC OCEAN

FIG.-15

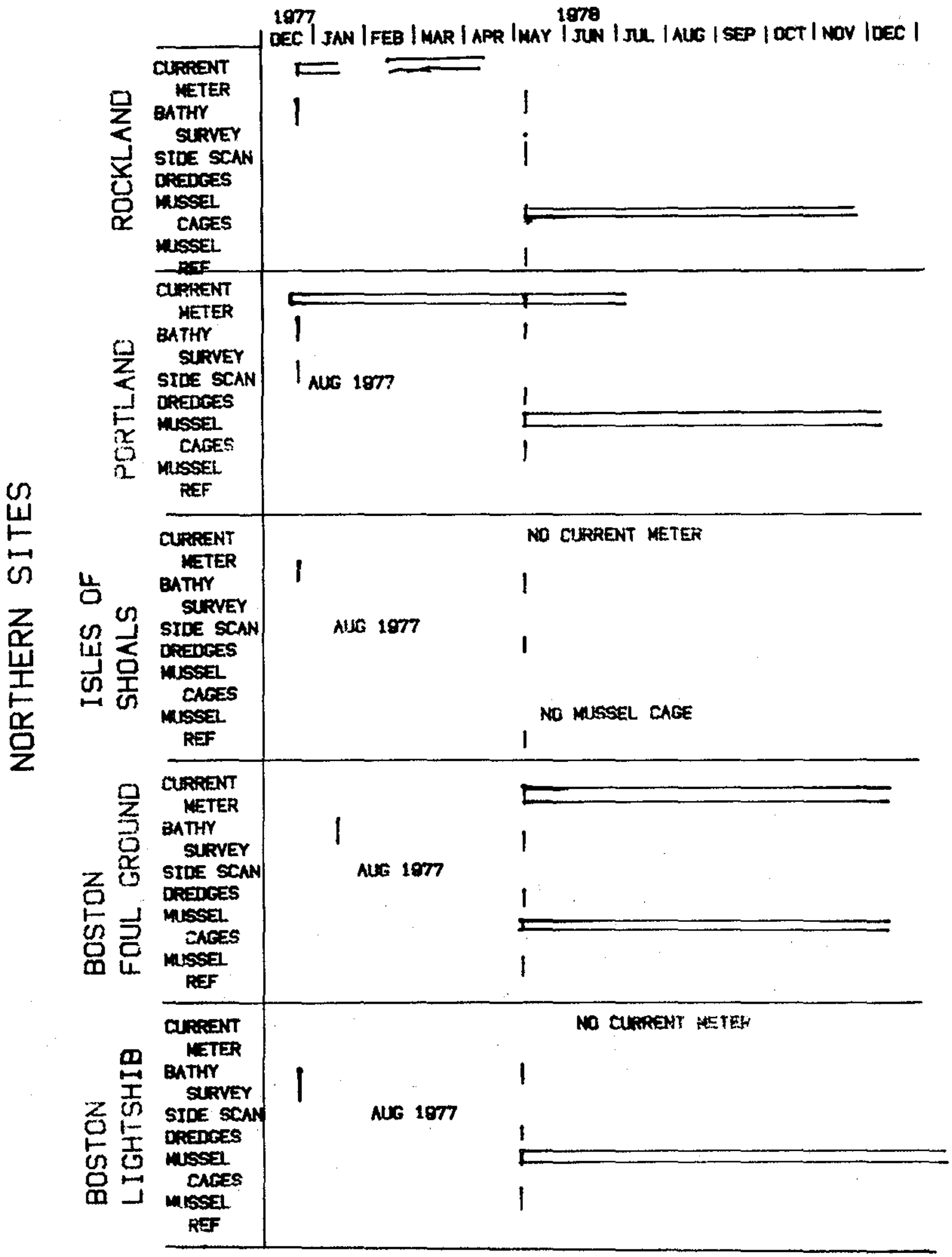
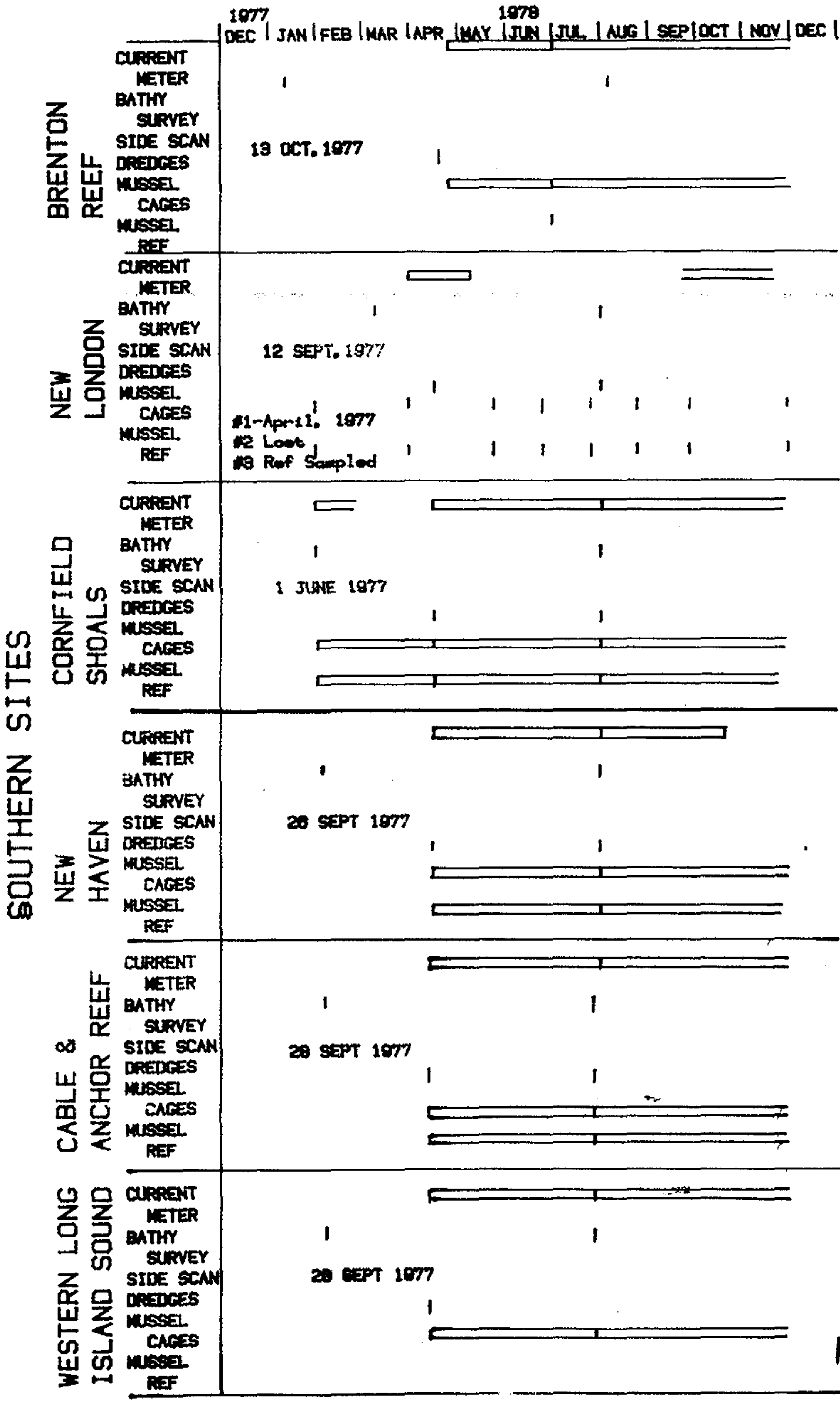

NORTHERN SITES
1977
1978
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
ROCKLAND
PORTLAND
ISLES OF SHOALS
BOSTON FOUL GROUND
BOSTON LIGHTSHIB
CURRENT METER
BATHY SURVEY
SIDE SCAN
DREDGES
MUSSEL CAGES
MUSSEL REF
AUG 1977
NO CURRENT METER
NO MUSSEL CAGE

FIG.-16A



1977
1978
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
SOUTHERN SITES
BRENTON REEF
NEW LONDON
CORNFIELD SHOALS
NEW HAVEN
CABLE & ANCHOR REEF
WESTERN LONG ISLAND SOUND
CURRENT METER
BATHY SURVEY
SIDE SCAN
DREDGES
MUSSEL CAGES
MUSSEL REF
13 OCT. 1977
12 SEPT. 1977
#1-April. 1977
#2 Lost
#3 Ref Sampled
1 JUNE 1977
28 SEPT 1977
28 SEPT 1977
28 SEPT 1977

FIG.-16B

APPENDIX

LIST OF TABLES

LIST OF TABLES (CONT'D)

Table 1

Ranking of sites in decreasing order of horizontal kinetic energy contained in the total observed current time series.

SITE	$K_{-H}(cm^2/sec^2)$
CORN	595.95
NLON	333.30
WLIS	184.28+
CAR	134.70
NHAV	125.86+
PORT	12.50

+ = Mean of two records

Table 2

% Of Total Motion Caused by Tidal Energy

WLIS	.90
NHAV	.86
CAR	.78
NLON	.78
PORT	.52
CORN	.43

Table 3

Average current and shear stress over 10 minute intervals

ACCELERATING FLOW		DECELERATING FLOW	
Mean Current cm/s	Mean Stress dynes/cm^2	Mean Current cm/s	Mean Stress dynes/cm^2
34.1	14.8	26.8	11.1
36.1	16.5	23.9	11.9
36.1	14.5	24.2	7.8
38.9	11.8	24.7	6.8
40.1	16.4	22.7	2.4

Table 4

Shear Stresses Measured in URI Water Tunnel

u cm	T_c Clauser dynes/cm^2	T_m Measured dynes/cm^2	T_t Theoretical dynes/cm^2	% Diff. Clauser vs. Measured	% Diff. Theoretical vs. Measured
15	0.461	0.40	0.48	15.3	20.0
22.5	0.886	0.80	1.00	10.8	25.0
30	1.463	1.31	1.68	11.7	28.2
45	2.52	2.62	3.51	3.8	34.0

Table 5

Turbulent Intensities and Relative Turbulent Intensities Measured In U.R.I. Water Tunnel.

u_E cm	$\sqrt{\bar{u}_x^2}$ cm/sec	$\sqrt{\bar{u}_x^2}/U_E$	Y for $\sqrt{\bar{u}_x^2}$ Max. cm	$\sqrt{\bar{u}_x^2}$ Max. cm/sec	$\sqrt{\bar{u}_x^2}$ Max / u_y (o.25 cm)
15	1.94	0.129	0.25	2.33	0.284
22.5	2.80	0.124	0.25	3.27	0.229
30	3.58	0.119	0.25	4.78	0.263
45	6.27	0.139	0.25	8.36	0.360

TABLE 6A

SURFACE SEDIMENT ANALYSIS

ROCKLAND MAINE

SAMPLING	Cd	Co	Cr	Cu	Fe*	Hg	Ni	Pb	Zn	Vol/Sol (%)	Oil/Grease (ppm)x10^3
	all metals ppm										
MAY 1978											
RH Cl-N2 (harbor)	.44	16	56	39	.25*	.15	47	53	129	8.8	5.2
R Ref 1	.54	9.5	40	15	1.6	.17	28	30	71	18.6	5.5
R Ref 2	.44	17	51	21	.26	.037	49	16	60	5.5	nil
R Ref 3	.26	10	41	8.9	1.6	.12	28	22	58	15.2	2.3
Rd (dump)	.45	11	46	12	1.6	.11	33	28	69	12.1	2.4

* all Fe values multiply by 10^4

TABLE 6B

SURFACE SEDIMENT ANALYSIS

PORTLAND MAINE

SAMPLING	Cd	Co	Cr	Cu	Fe*	Hg	Ni	Pb	Zn	Vol/Sol (%)	Oil/Grease (ppm) x 10^3
	all metals ppm										
May 1978											
PD (dump)	.40	4.7	24	3.1	.89	.025	13	7.9	22	3.4	nil
TB 1 turn base	2.3	11	57	41	2.3	.38	36	77	139	11.5	2.1
PH 4 harbor CG	1.2	11	64	39	2.5	.52	37	71	131	21.6	6.8
PRPH harbor	.62	11	62	28	2.2	.31	33	53	104	16.0	.8
DPH harbor	.22	14	48	16	2.6	.37	32	15	76	4.5	nil

* all Fe values multiply by 10^4

TABLE 6C

SURFACE SEDIMENT ANALYSIS

ISLES OF SHOALS & PISCATAQUA RIVER

SAMPLING	Cd	Co	Cr	Cu	Fe*	Hg	Ni	Pb	Zn	Vol/Sol	Oil/Grease
	all metals ppm									(%)	(ppm) x 10^3
MAY 1978											
IS 1	.43	7.4	36	6.6	1.2	.060	20	15	37	5.2	.2
IS 2	.59	8.7	40	7.6	1.6	.037	25	13	44	5.1	.1
IS 3	.31	8.3	43	8.3	1.5	.050	25	18	47	7.4	.2
PR B5-B6 base	.45	6.6	60	80	1.1	.43	26	150	272	4.4	nil
PR-LB5	1.0	6.2	19	8.4	.58	.30	17	34	40	10.6	nil
PRDB	.36	8.6	40	450	1.8	.20	27	133	55	8.1	nil
PRNB-12 base	.45	5.8	61	26	.95	.33	21	47	94	8.8	nil
ERROR %	25	9	5	7	3	14	5	13	15	5	15

* all Fe values multiply by 10^4

TABLE 6D

SURFACE SEDIMENT ANALYSIS

BOSTON MASS

SAMPLING	Cd	Co	Cr	Cu	Fe*	Hg	Ni	Pb	Zn	Vol/Sol	Oil/Grease
	all metals ppm									(%)	(ppm x 10^3)
MAY 1978											
BFA 1	.39	11	87	17.2	2.4	.29	34	46	85	19.1	nil
BFA 3	.49	11	87	25.6	2.2	.19	33	58	100	16.2	nil
BLDS 1	.26	8.9	38	16.7	1.6	.049	21	18	48	3.0	1.1
BLDS 2	.54	11	69	46.3	1.9	.55	25	101	126	6.9	2.6

* all Fe values multiply by 10^4

TABLE 6E

SURFACE SEDIMENT ANALYSIS

BRENTON REEF R.I.

SAMPLING	Cd	Co	Cr	Cu	Fe*	Hg	Ni	Pb	Zn	Vol/Sol (%)	Oil/Grease (ppm x 10^3)
	all metals ppm										
APRIL 1978											
BR Ref	.12	2.4	7.2	2.6	.61	.01	11	8.4	17	1.6	2.2
BR 1	.24	5.0	14	6.0	1.4	.01	29	7.2	31	4.1	nil
BR 2	.12	2.3	3.1	2.0	.46	nil	13	2.3	8.1	2.1	.48
AUGUST 1978											
BR Ref	.12	1.9	13	2.5	.54	nil	4.2	8.9	17	2.3	.34
BR	.12	3.9	24	11	.94	.03	8.7	13	36	8.3	.27

* all Fe values multiply by 10^4

TABLE 6F

SURFACE SEDIMENT ANALYSIS

CORNFIELD SHOAL CT.

SAMPLING	Cd	Co	Cr	Cu	Fe*	Hg	Ni	Pb	Zn	Vol/Sol	Oil/Grease
	all metals ppm									(%)	(ppm x 10^3)
MAR/APR 1978											
CORN CS 1	.12	2.9	5.6	2.8	.66	.01	21	8.9	28	.93	.05
CORN DS 1 dump	.11	2.6	8.1	4.3	.45	.07	18	4.5	28	1.1	7.6
CORN DS 2 dump	1.7	7.3	56	59	1.5	.29	41	52	144	7.0	3.0
CORN DS 3 dump	.12	5.3	6.3	4.6	.82	.04	38	14	35	5.2	1.4
CORN NM 2	.24	5.1	6.8	9.4	.66	.04	39	14	28	5.5	.35
CORN SM 4	.25	3.7	6.3	5.8	.62	.02	21	11	24	2.7	nil
CORN WM 5	.12	2.9	6.5	4.0	.42	.16	13	5.8	22	.9	nil
ERROR %	25	9	5	7	3	14	5	13	15	5	15
JULY 1978											
CORN 1	.37	4.4	30	15	1.0	.05	14	12	53	5.0	.61
CORN 2	4.0	8.5	93	82	1.6	.64	31	83	281	24	6.3
CORN Ref 1	.25	2.4	11	1.7	.56	nil	6.1	7.5	27	1.7	.52

* All Fe values multiply by 10^4

TABLE 6G

SURFACE SEDIMENT ANALYSIS

NEW HAVEN DUMP SITE

SAMPLING	Cd	Co	Cr	Cu	Fe*	Hg	Ni	Pb	Zn	Vol/Sol (%)	Oil/Grease (ppm)x 10^3
				all metals ppm							
MARCH 1977											
SW of Dump	2.6		185	146		.69		86	267	9.4	2.8
Dump NH 1	1.7		140	117		.66		76	226	9.9	2.6
NH Ref	nil		102	72		.97		49	138	9.3	.4
APRIL 1978											
NH Ref	.5	11	63	70	2.5	.25	52	57	161	11	1
NH 1	.49	5.3	36	50	1.1	.17	27	30	92	4.1	1.3
NH 2	.61	6.1	33	43	1.1	.20	30	28	82	3.1	1.9
NH 3	.83	5.8	43	72	1.2	.39	34	36	123	7.5	1.9
JULY 1978											
NH Ref	.75	9.5	87	81	1.8	.36	25	55	195	11	
NH 1	.62	7.1	44	43	1.2	.17	16	28	97	7.4	
% S. D. #	25	9	5	7	3	14	5	13	15	5	15

* All Fe values multiply by 10^4

\# %S.D. = S.D. x 10^2/mean

TABLE 6H

LONG ISLAND SOUND DUMP SITES

SURFACE SEDIMENT ANALYSIS

SAMPLING	Cd	Co	Cr	Cu	Fe*	Hg	Ni	Pb	Zn	Vol/Sol	Oil/Grease
					all metals ppm					(%)	(ppm)
APRIL 1978					CABLE AND ANCHOR REEF						
CAR Ref 3	.31	8.1	31	20	1.2	.18	14	17	70	3.0	
CAR 1	.37	9.6	43	60	2.0	.30	55	59	144	11	6.8
CAR 3	.86	8.0	52	69	1.6	.56	49	75	138	7.0	1.6
					WESTERN LONG ISLAND SOUND						
WLIS 1	.61	4.4	34	43	1.3	.23	32	34	110	7.6	.9
WLIS 2	.62	8.3	39	49	1.5	.26	41	43	121	8.1	4.8
WLIS 3	.36	7.6	35	48	1.5	.18	35	35	111	6.8	1.8
WLIS R1	.25	8.7	39	60	1.8	.28	41	29	124	6.2	.9
JULY 1978					CABLE AND ANCHOR REEF						
CAR 1	.83	8.5	74	78	1.6	.69	22	69	184	19	
CAR 2	.72	7.8	64	61	1.6	.69	22	64	169	12	
CAR 3	.99	9.5	84	86	1.7	.48	26	71	218	22	
CAR, WLIS Ref 1	.75	8.7	73	76	1.6	.28	21	45	173	15	
WLIS 1	.50	8.0	58	61	1.4	.22	18	37	147	8.7	
% S.D.	25	9	5	7	3	14	5	13	15	5	15

* all Fe values multiply by 10^4

TABLE 7 COMPARISON OF HEAVY METAL CONCENTRATIONS IN *MYTILUS EDULIS* COLLECTED FROM LATIMER'S LIGHT AND NEW HAVEN WITH DATA OBTAINED FROM THE MUSSEL WATCH PROGRAM (GOLDBERG ET.AL., ENVIRONMENTAL CONSERVATION, 5(2), 101-125, 1978).

	FROM THIS STUDY		FRM THE MUSSEL WATCH PROGRAM				
	LATIMER'S LIGHT	NEW HAVEN	NARRAGANSETT BAY	SAKONNET PT.	BLOCK IS.	MILLSTONE	NEW HAVEN
CU	8.53-10.80	10.20-19.86	6.7-12.0	4.4	6.1	7.6	11.0
CD	1.37- 2.18	2.25- 2.90	1.2- 1.9	2.2	1.2	1.8	6.2
PB	5.17- 8.58	5.53- 7.90	2.5- 6.0	1.5	1.9	2.3	4.7
ZN	110 - 162	119 - 223	81 - 199	122	84	139	142

Table 8

DAMOS
NORTHERN SITES

Gulf of Maine

Site	Dates Sampled
Rockland	12 Dec 1977
Portland	15 Dec 1977
Isle of Shoals	17 Dec 1977
Boston Foul Ground	18 Dec 1977
Boston Lightship	18 Dec 1977

SOUTHERN SITES

Rhode Island Sound

Brenton Reef	25 Apr 1978
Brenton Reef Reference Station	19 Apr 1978

Long Island Sound

New London Dump Site	17 Apr 1978
New London Reference Station	17 Apr 1978
Cornfield Shoals Dump Site	31 Jan 1978
Cornfield Shoals Reference Station	31 Jan 1978
New Haven Dump Site	13 Apr 1978
New Haven Reference Station	13 Apr 1978
Cable and Anchor Reef Dump Site	11 Apr 1978
Western Long Island Sound Dump Site	12 Apr 1978
CAR - WLIS Reference Station	12 Apr 1978

TABLE 9 A

MASTER SPECIES LIST - GULF OF MAINE STATIONS

Species	Occurence/ 15 Samples	No. Individuals
Phylum PORIFERA		
1. Iophon nigricans	2	2+
Phylum CNIDARIA		
Cl. Hydrozoa		
2. Hydractinia sp.	1	1+
Cl. Anthozoa		
3. Cerianthus (borealis)	3	3
4. Cerianthus sp.	2	4
5. Edwardsia (elegans)	8	48
Phylum NEMATODA		
6. NEMATODE sp.	5	7
Phylum PLATYHELMINTHES		
7. PLATYHELMINTH sp.	3	3
Phylum RYNCHOCOELA		
8. Amphiporus (caecus)	1	1
9. Amphiporus sp.	1	2
10. Cerebratulus sp.	5	9
11. Micrura sp.	9	36
12. Tubulanus sp.	2	3
Phylum PRIAPULIDA		
13. Priapulus caudatus	1	1
Phylum MOLLUSCA		
Cl. Aplacophora		
14. Chaetoderma nitidulum	6	20
15. Chaetoderma sp.	1	1
Cl. Gastropoda		
16. Alvania carinata	1	3
17. Colus pygmaeus	2	2
18. Colus stimpsoni	1	1
19. Lunatia pallida	1	1
20. Nassarius trivittatus	1	1
21. Philine quadrata	1	1
22. Propebela concinnula	4	6
23. Retusa obtusa	1	1
24. Scaphander punctostriatus	2	5
Cl. Pelecypoda		
25. Arctica islandica	2	38
26. Astarte subaequilatera	6	57
27. Astarte undata	4	129
28. Cerastoderma pinnulatum	4	6
29. Crenella glandula	2	2
30. Cuspidaria obesa	1	1
31. Cyclocardia borealis	3	55

Species	Occurence/ 15 Samples	No. Individuals
32. Macoma calcarea	2	2
33. Macoma sp.	1	1
34. Musculus niger	1	2
35. Nucula proxima	2	1024
36. Nucula tenuis	3	5
37. Nuculana tenuisulcata	7	13
38. PECTINIID sp.	1	1
39. Tellina versicolor	1	1
40. Thracia conradi	5	7
41. Thracia sp. (juv.)	2	7
42. Thyasira (gouldii)	8	19
43. Yoldia lucida	5	16
44. Yoldia sapotilla	4	6
45. Yoldia thraciaeformis	3	5
Phylum ANNELIDA		
Cl. Polychaeta		
46. Ampharete acutifrons	12	143
47. Ampharete arctica	2	6
48. Amphicteis gunneri	1	1
49. Amphitrite cirrata	3	7
50. Ancistrosyllis groenlandica	2	2
51. Aphrodita hastata	2	2
52. Brada granosa	2	4
53. Brada villosa	1	1
54. Chaetozone setosa	1	1
55. Cirriformia grandis	1	1
56. CIRRATULID sp.	1	1
57. Clymenella torquata	1	6
58. Clymenella zonalis	1	1
59. Diplocirrus hirsutus	1	1
60. Drilonereis magna	4	4
61. Enipo gracilis	2	6
62. Euclymene sp.	4	7
63. Gattyana cirrosa	1	1
64. Goniada maculata	11	56
65. Harmathoe imbricata	3	4
66. Hartmania moorei	7	9
67. Heteromastus filiformis	1	1
68. Laonice cirrata	3	8
69. Laonome kroyeri	1	1
70. Lumbriclymene cylindricauda	2	3
71. Lumbrincris fragilis	12	66
72. Lumbrineris tenuis	3	10
73. Lumbrineris (tenuis)	1	4
74. Maldane sarsi	11	53
75. Maldanposis elongata	1	1
76. Melinna cristata	8	37
77. Myriochele heeri	10	96
78. Nephtys ciliata	4	6
79. Nephtys (ciliata)	1	1
80. Nephtys incisa	13	87

Species	Occurence/ 15 Samples	No. Individuals
81. Nephtys paradoxa	1	1
82. Nephtys picta	1	1
83. Nicomache lumbricalis	5	12
84. Ninoe nigrippes	12	102
85. Owenia fusiformis	3	7
86. Paraonis gracilis	1	1
87. Petaloproctus tenuis	1	1
88. Pherusa plumosa	2	5
89. Pherusa sp.	1	1
90. Pista cristata	5	17
91. Polyphysia crassa	1	1
92. Potamilla reniformis	1	1
93. Praxillella gracilis	9	87
94. Praxillella praetermissa	4	27
95. Rhodine loveni	2	6
96. Sabella (microphthalma)	1	5
97. Scalibregma inflatum	3	3
98. Scoloplos acutus	3	10
99. Spio filicornis	8	25
100. Spiophanes (kroveri)	1	1
101. Sternaspis scutata	11	273
102. Syllis cornutus	2	3
103. Terebellides stroemi	6	16
104. Tharyx acutus	1	1
105. Tharyx sp.	4	5
106. Theleppus cincinnatus	2	4
107. Trichobranchus glacialis	3	5
108. Trochochaeta watsoni	2	2
Phylum SIPUNCULIDA		
109. Phascolion strombi	4	7
Phylum ARTHROPODA		
Cl. Crustacea		
Subcl. Malacostraca		
O. Isopoda		
110. Calathura branchiata	2	13
111. Cirolana polita	1	1
112. Gnathia cerina	1	2
O. Cumacea		
113. Diastylis quadrispinosa	1	1
114. DIASTYLID sp.	1	1
O. Amphipoda		
115. Ampelisca macrocephala	1	1
116. Byblis serrata	6	11
117. Casco bigelowi	4	5
118. Haploops tubicola	6	20
119. Hippomedon propinquus	1	1
120. Hippomedon serratus	3	7
121. Leptocheirus pinguis	3	10

Species	Occurence/ 15 Samples	No. Individuals
122. Melita dentata	3	3
123. Unciola irrorata	3	23
O. Decapoda		
124. Pagurus longicarpus	2	2
Phylum BRACHIOPODA		
125. Terebratulina septentrionalis	2	3
Phylum PHORONIDA		
126. Phoronis (architecta)	2	2
Phylum BRYOZOA		
127. Callopora aurita	1	1+
Phylum ECHINODERMATA		
Cl. Stelleroidea		
128. Ctenodiscus crispatus	7	37
129. Ophiocantha bidentata	2	3
130. Ophiopholis aculeata	1	1
131. Ophiura robusta	1	1
132. Ophiura sarsi	9	43
Cl. Holothuroidea		
133. Molpadia oolitica	3	12
Phylum CHORDATA		
134. Bostrichobranchus (pilularis)	1	1

TABLE 10

DAMOS DATA SUMMARY - TOTAL DISTRIBUTION - GULF OF MAINE STATIONS

WINTER COLLECTIONS 1977-78

Total No. Phyla: 15
Total No. Species: 134
Total No. Individuals: 3032

PREDOMINANT SPECIES LIST

	SPECIES	PHYLA	FEEDING TYPE	OCCURRENCE/ 15 SAMPLES	TOTAL NO. INDIVIDUALS	% TOTALS	CUMUL. %
1.	Nucula Proxima	M	DF	2	1024	33.7	33.7
2.	Sternaspis scutata	A	DF	11	273	8.7	42.4
3.	Ampharete acutifrons	A	DF	12	143	4.6	47.0
4.	Astarte undata	M	SF	4	129	4.1	51.1
5.	Ninoe nigrippes	A	C	12	102	3.3	54.4
6.	Myriochele heeri	A	DF	10	96	3.1	57.5
7.	Nephthys incisa	A	DF	13	87	2.8	60.3
8.	Praxillella gracilis	A	DF	9	87	2.8	63.1
9.	Lumbrineris fragilis	A	C	12	66	2.1	65.2
10.	Astarte subaequilatera	M	SF	6	57	1.8	67.0
11.	Goniada maculata	A	C	11	56	1.8	68.8

A: ANNELIDA
M: MOLLUSCA
SF: SUSPENSION FEEDER

DF: DEPOSIT FEEDER
C: CARNIVOROUS

TABLE 11

DAMOS DATA SUMMARY - TOTAL DISTRIBUTION - GULF OF MAINE

WINTER COLLECTIONS - 1977-78

	ROCKLAND MAINE DUMPSITE		PORTLAND MAINE DUMPSITE			ISLE OF SHOALS DUMPSITE			
No. of Species Per Sample	16	10	54	18	50	35	21	51	48
No. of Individuals Per Sample	790	301	300	26	361	109	71	236	401
No. of Phyla Per Station	4		10			11			
No. of Species Per Station	20		71			78			
No. of Individuals Per Station	1091		687			817			

	BOSTON FOUL GROUND DUMPSITE			BOSTON LIGHTSHIP DUMPSITE		
	#1	#2	#3	#1	#2	#3
No. of Species Per Sample	9	31	21	31	29	9
No. of Individuals Per Sample	18	97	64	126	119	13
No. of Phyla Per Station		6			11	
No. of Species Per Station		39			47	
No. of Individuals Per Station		179			258	

TABLE 12 A

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION ROCKLAND, MAINE DATE 12 DECEMBER 1977

PREDOMINANT SPECIES	DREDGE 1	NUMBER 2	TOTAL	MEAN	STD DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1. Nucula proxima	736	288	1024	512.0	316.8	196.0	----	1	93.9	93.9
2. Nephthys incisa	13	3	16	8	7.1	6.3	----	2	1.5	95.4
3.										
4.										
5.										
6.										
7.										
8.										
9.										
10.										
11.										
12.										
13.										
14.										
15.										
16.										
17.										
18.										
TOTAL	749	291	1040	520.0	323.9	201.7	----			
TOTAL NO. OF SPP. PER DREDGE	16	10	20	13.0	4.2		----			
SPECIES DIVERSITY (H')	0.41	0.27	0.68	0.34	0.10					
EQUITABILTIY (J')	0.15	0.12	0.27	0.14	0.02					

TOTAL NO. OF INDIVIDUALS THIS STN = 1091

TABLE 12 B

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION PORTLAND, MAINE   DATE 15 DECEMBER 1977

PREDOMINANT SPECIES	DREDGE 1	2	NUMBER 3	TOTAL	MEAN	STD DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF.LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1. Astarte undata	70	4	52	126	42.0	34.1	27.7	0-126.7	1	18.3	18.3
2. Cyclocardia borealis	41	2	12	55	18.3	20.3	22.5	0- 68.7	2	8.0	26.3
3. Astarte subaequilatera	27	2	22	51	17.0	13.2	10.2	0- 49.8	3	7.4	33.7
4. Lumbrineris fragilis	12	1	27	40	13.3	13.1	12.9	0- 45.8	4	5.8	39.5
5. Arctica islandica	3	0	35	38	12.7	19.4	29.6	0- 60.9	5	5.5	45.0
6. Ninoe nigrippes	10	0	25	35	11.7	12.6	13.6	0- 43.0	6	5.1	50.1
7. Ampharete acutifrons	12	1	15	28	9.3	7.4	5.9	0- 27.7	7	4.1	54.2
8. Unciola irrorata	5	0	17	22	7.3	8.7	10.4	0- 28.9	8	3.2	57.4
9. Goniada maculata	7	0	14	21	7.0	7.0	7.0	0- 24.4	9	3.1	60.5
10. Nephthys incisa	10	1	7	18	6.0	4.6	3.5	0- 17.4	10	2.6	63.1
11. Ophiura sarsi	11	1	6	18	6.0	5.0	4.2	0- 18.4	10	2.6	65.7
12. Myriochele heeri	6	0	8	14	4.7	4.2	3.8	0- 15.1	11	2.0	67.7
13.											
14.											
15.											
16.											
17.											
18.											
TOTAL	214	12	240	466	155.3	124.8	100.3	0-465.3			
TOTAL NO. OF SPP. PER DREDGE	54	18	50	71	40.7	19.7		0- 89.6			
SPECIES DIVERSITY (H')	3.08	2.78	3.29	9.15	3.05	0.26					
EQUITABILITY (J')	0.77	0.96	0.84	2.57	0.86	0.10					

TOTAL NO. OF INDIVIDUALS THIS STN = 687

TABLE 12 C

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION ISLE OF SHOALS, NEW HAMPSHIRE — DATE 17 DECEMBER 1977

PREDOMINANT SPECIES	DREDGE NUMBER 1	2	3	4	TOTAL	MEAN	STD DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF.LIMITS OF MEAN	NUMERIC RANK	% OF STN TOTAL	CUMUL. % OF TOTAL
1. Sternaspis scutata	18	13	28	96	155	38.8	38.7	38.6	0-100.4	1	19.0	19.0
2. Ampharete acutifrons	12	6	44	44	106	26.5	20.4	15.7	0- 59.0	2	13.0	32.0
3. Praxillella gracilis	9	10	10	41	70	17.5	15.7	14.1	0- 42.5	3	8.6	40.6
4. Myriochela heeri	7	3	5	54	69	17.3	24.6	35.0	0- 56.4	4	8.4	49.0
5. Edwardsia (elegaus)	4	6	9	14	33	8.3	4.3	2.2	1.5-15.1	5	4.0	53.0
6. Ctenodiscus crispatus	5	0	8	14	27	6.8	5.9	5.1	0- 16.2	6	3.3	56.3
7. Praxillella praetermissa	0	1	14	11	26	6.5	7.0	7.5	0- 17.6	7	3.2	59.5
8. Ninoe nigrippes	4	2	9	11	26	6.5	4.2	2.7	0- 13.2	8	3.2	62.7
9. Maldane sarsi	1	5	16	2	24	6.0	6.9	7.9	0- 17.0	9	2.9	65.6
10. Melinna cristata	1	1	16	6	24	6.0	7.1	8.4	0- 17.3	10	2.9	68.5
11. Ophiura sarsi	4	0	8	8	20	5.0	3.8	2.9	0- 11.1	10	2.4	70.9
12. Goniada maculata	5	2	2	9	18	4.5	3.3	2.4	0- 9.8	11	2.2	73.1
13. Spio filicornis	1	0	4	13	18	4.5	5.9	7.7	0- 13.9		2.2	75.3
14. Nephthys incisa	1	3	7	5	16	4.0	2.6	1.7	0- 8.1		2.0	77.3
15.												
16.												
17.												
18.												
TOTAL	72	52	180	328	632	158.0	126.5	101.3	0-359.3			
TOTAL NO. OF SPP. PER DREDGE	35	21	51	48	78	38.8	13.7		17.0-60.6			
SPECIES DIVERSITY (H')	3.10	2.68	3.16	8.94	8.94	2.98	0.26					
EQUITABILITY (J')	0.87	0.88	0.80	0.74	2.49	0.83	0.08					

TOTAL NO. OF INDIVIDUALS THIS STN = 817

TABLE 12 D

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION BOSTON FOUL GROUND | DATE 18 DECEMBER 1977

PREDOMINANT SPECIES	DREDGE NUMBER 1	2	3	TOTAL	MEAN	STD DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF.LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1. Ninoe nigrippes	7	11	8	26	8.7	2.1	0.5	3.5-13.9	1	14.5	14.5
2. Sternaspis scutata	0	8	15	23	7.7	7.5	7.3	0-26.3	2	12.8	27.3
3. Praxillella gracilis	0	7	7	14	4.7	4.0	3.4	0-14.6	3	7.8	35.1
4. Molpadia oolitica	0	5	6	11	3.7	3.2	2.8	0-11.7	4	6.1	41.2
5. Lumbrineris tenuis	1	7	2	10	3.3	3.2	3.2	0-11.3	5	5.6	46.8
6. Myriodule heeri	0	5	4	9	3.0	2.6	2.3	0- 9.5	6	5.0	51.8
7. *Yoldia lucida*	0	7	2	9	3.0	3.6	4.3	0-11.9	6	5.0	56.8
8. Scoloplos acutus	0	6	2	8	2.7	3.1	3.6	0-10.4	7	4.5	61.3
9. Micrura sp.	0	5	2	7	2.3	2.5	2.7	0- 8.5	8	3.9	65.2
10. Ctenodiscus crispatus	1	5	0	6	2.0	2.6	3.4	0- 8.5	9	3.4	68.6
11. Goniada maculata	2	3	0	5	1.7	1.5	1.3	0- 5.4	10	2.8	71.4
12. Nucula tenuis	0	2	2	4	1.3	1.2	1.1	0- 4.3	11	2.2	73.6
13. Spio filicornis	1	2	1	4	1.3	0.6	0.3	0- 2.8	11	2.2	75.8
14. Yoldia thraciaeformis	0	2	2	4	1.3	1.2	1.1	0- 4.3	11	2.2	78.0
15. Nephthys incisa	1	2	0	3	1.0	1.0	1.0	0- 3.5	12	1.7	79.7
16. Ophiura sarsi	0	0	3	3	1.0	1.7	2.9	0- 5.2	12	1.7	81.4
17.											
18.											
TOTAL	13	77	56	146	48.7	32.6	21.9	0-129.7			
TOTAL NO. OF SPP. PER DREDGE	9	31	20	39	20.0	11.0		0- 47.3			
SPECIES DIVERSITY (H')	1.87	3.12	2.59	7.58	2.53	0.63					
EQUITABILITY (J')	0.85	0.91	0.87	2.63	0.88	0.03					

TOTAL NO. OF INDIVIDUALS THIS STN = 179

TABLE 12 E

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION BOSTON LIGHTSHIP — DATE 18 DECEMBER 1977

PREDOMINANT SPECIES	DREDGE NUMBER 1	2	3	TOTAL	MEAN	STD DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF.LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1. Sternaspis scutata	47	32	0	79	26.3	24.0	21.9	0-85.9	1	30.6	30.6
2. Nephthys incisa	14	20	0	34	11.3	10.3	9.4	0-36.9	2	13.2	43.8
3. Micrura sp.	5	11	0	16	5.3	5.5	5.7	0-19.0	3	6.2	50.0
4. Maldane sarsi	6	8	1	15	5.0	3.6	2.6	0-13.9	4	5.8	55.8
5. Lumbrineris fragilis	7	6	0	13	4.3	3.8	3.4	0-13.7	5	5.0	60.8
6. Ninoe nigrippes	10	3	0	13	4.3	5.1	6.0	0-17.0	5	5.0	65.8
7. Goniada maculata	2	5	5	12	4.0	1.7	0.7	0- 8.2	6	4.7	70.5
8. Edwardsia (elegans)	1	7	0	8	2.7	3.8	5.3	0-12.1	7	3.1	73.6
9. Ampharete acutifrons	3	1	1	5	1.7	1.2	0.8	0- 4.7	8	1.9	75.5
10. Hippomedon serratus	4	1	0	5	1.7	2.1	2.6	0- 6.9	8	1.9	77.4
11.											
12.											
13.											
14.											
15.											
16.											
17.											
18.											
TOTAL	99	94	7	200	66.7	51.7	40.1	0-195.1			
TOTAL NO. OF SPP. PER DREDGE	31	29	9	47	23.0	12.2		0- 53.3			
SPECIES DIVERSITY (H')	2.52	2.61	1.95	7.08	2.36	0.36					
EQUITABILITY (J')	0.73	0.77	0.89	2.39	0.80	0.08					

TOTAL NO. OF INDIVIDUALS THIS STN = 258

TABLE 13

DAMOS DATA SUMMARY - TOTAL DISTRIBUTION

WINTER COLLECTIONS 1977-78

STATION	MEAN NO. SPECIES	STD DEV	95% CONF INTERVALS	MEAN NO. INDIVIDUALS	STD DEV	95% CONF INTERVALS	NO. OF SAMPLES
GULF OF MAINE							
ROCKLAND ME. DUMP SITE	13.0	4.2	---	545.5	345.8	---	2
PORTLAND ME. DUMP SITE	40.7	19.7	0-89.6	229.0	178.4	0-672.3	3
ISLE OF SHOALS DUMP SITE	38.8	13.7	17.0-60.6	204.3	148.9	0-441.2	4
BOSTON LIGHTSHIP DUMP SITE	23.0	12.2	0-53.3	86.0	63.3	0-243.3	3
BOSTON FOUL GRD. DUMP SITE	20.0	11.0	0-47.3	59.7	39.7	0-158.3	3

TABLE 14

MASTER SPECIES LIST - R. I. Sound Stations

Species	Occurrence/ 6 Samples	No. Individuals
Phylum CNIDARIA		
Cl. Hydrozoa		
1. Campanularia (flexuosa)	1	1+
2. Halecium sp.	2	2+
3. Thuiaria sp.	1	1+
Cl. Anthozoa		
4. ACTINIARIA sp.(developing)	3	7
5. Cerianthus sp.	4	9
6. Edwardsia (elegans)	3	33
Phylum RYNCHOCOELA		
7. Cerebratulus sp.	3	8
8. Lineus sp.	1	1
9. Micrura sp.	3	13
10. Tubulanus sp.	1	1
11 RYNCHOCOELA sp.	1	1
Phylum NEMATODA		
12. NEMATODA sp.	1	1
Phylum MOLLUSCA		
Cl. Gastropoda		
13. Mitrella sp.	1	1
Cl. Pelecypoda		
14. Arctica islandica	2	3
15. Arctica islandica (juv.)	1	2
16. Astarte (undata)	1	1
17. Cerastoderma pinnulatum	1	2
18. Mytilus edulis	1	1
19. Nucula proxima	3	7
20. Periploma fragile	3	22
21. Spisula solidissima	1	2
22. Pitar morrhuana	3	5
23. Tellina agilis	1	1
24. Yoldia sapotilla	1	1
25. PELECYPODA sp.	1	1
Phylum ANNELIDA		
Cl. Polychaeta		
26. Aglaophamus circinata	2	6
27. Ammotrypane aulogaster	3	41
28. Ampharete acutifrons	3	614
29. Ampharete arctica	2	11
30. Chone infundibuliformis	3	353
31. CIRRATULID sp.	2	4
32. Clymenella torquata	1	4

Species	Occurrence/ 6 Samples	No. Individuals
33. CLYMENELLINAE sp.	1	1
34. Drilonereis magna	1	1
35. Eteone flava	1	1
36. Eteone longa	1	1
37. Euchone rubrocincta	2	3
38. Glycera americana	1	1
39. Goniada maculata	1	1
40. Laonome kroyeri	1	1
41. Lumbriclymene cylindricauda	1	1
42. Lumbrineris fragilis	1	5
43. Lumbrineris tenuis	2	6
44. MALDANID sp.	2	2
45. Maldanopsis elongata	1	3
46. Nephthys incisa	4	37
47. Nephthys sp.	1	1
48. Nereis succinea	1	1
49. Nereis zonata	1	1
50. Ninoe nigrippes	5	183
51. Paranaitis sp.	1	1
52. Pherusa affinis	3	64
53. Pholoe minuta	2	4
54. Pista cristata	1	3
55. Polycirrus sp.	1	1
56. SABELLID sp.	1	1
57. Scalibregma inflatum	4	52
58. Spiophanes bombyx	1	3
59. Terebellides stroemi	1	12
Phylum ARTHROPODA		
Cl. Crustacea		
Subcl. Malacostraca		
O. Cumacea		
60. Diastylis sculpta	3	27
61. DYASTYLID sp.	1	5
62. Eudorella emarginata	3	70
O. Amphipoda		
63. Aeginina longicornis	2	2
64. Ampelisca abdita	2	9
65. Ampelisca agassiyi	3	8080
66. Ampelisca macrocephala	1	1
67. Ampelisca vadorum	2	8
68. Byblis serrata	3	11
69. Casco bigelowi	3	6
70. Corophium crassicorne	3	5
71. Erichthonius rubricornis	2	3
72. Harpinia propingua	3	32
73. Leptocheirus pinguis	2	289
74. Oediceros sp.	1	1
75. Orchomenella minuta	2	2
76. Photis dentata	1	2

T14 B

Species	Occurrence/ 6 Samples	No. Individuals
77. Phoxocephalus holbolli	2	4
78. Trichophoxus epistomus	1	1
79. Unciola irrorata	5	354
O. Decapoda		
80. Cancer irroratus	2	2
Phylum PHORONIDA		
81. Phoronis architecta	1	2
Phylum ECHINODERMATA		
Cl. Holothuroidea		
82. APODIDA sp.	2	3
Phylium CHORDATA		
83. Bostrichobranchus sp.	1	3

T-INC

TABLE 15

DAMOS DATA SUMMARY - TOTAL DISTRIBUTION - R.I. SOUND STATIONS

SPRING COLLECTIONS - 1978

TOTAL NO. PHYLA: 9
TOTAL NO. SPECIES: 83
TOTAL NO. INDIVIDUALS: 10473

TOTAL NO. INDIVIDUALS (CORRECTED FOR AMPELISCA AGASSIZI): 2393

PREDOMINANT SPECIES LIST

SPECIES	PHYLA	FEEDING TYPE	OCCURRENCE/ 6 SAMPLES	TOTAL NO. INDIVIDUALS	% TOTALS	CUMUL. %
1. Ampelisca agassizi	AR	SF	3	8080	77.2	77.2
2. Ampharete acutifrons	A	DF	3	614	5.9	83.1
3. Unciola irrorata	AR	DF	5	354	3.4	86.5
4. Chone infundibuliformis	A	SF	3	353	3.4	89.9
5. Leptocheirus pinguis	AR	DF	2	289	2.8	92.7

PREDOMINANT SPECIES LIST (CORRECTED FOR A. AGASSIZI)

SPECIES	PHYLA	FEEDING TYPE	OCCURRENCE/ 6 SAMPLES	TOTAL NO. INDIVIDUALS	% TOTALS	CUMUL. %
1. Ampharete acutifrons	A	DF	3	614	25.7	25.7
2. Unciola irrorata	AR	DF	5	354	14.8	40.5
3. Chone infundibuliformis	A	SF	3	353	14.8	55.3
4. Leptocheirus pinguis	AR	DF	2	289	12.1	67.4
5. Ninoe nigrippes	A	C	5	183	7.6	75.0
6. Eudorella emarginata	AR	SF	3	70	2.9	77.9
7. Pherusa affinis	A	DF	3	64	2.7	80.6

AR: ARTHROPODH
A : ANNELIDA
SF: SUSPENSION FEEDER

DF: DEPOSIT FEEDER
C : CARNIVOROUS

TABLE 16

DAMOS DATA SUMMARY - TOTAL DISTRIBUTION - R.I. SOUND

SPRING COLLECTIONS - 1978

	BRENTON REEF DUMPSITE			BRENTON REEF REFERENCE		
	#1	#2	#3	#1	#2	#3
NO. OF SPECIES PER SAMPLE	9	2	6	40	48	49
NO. OF INDIVIDUALS PER SAMPLE	18	2	11	2481	4393	3568
NO. OF PHYLA PER STATION		7			8	
NO. OF SPECIES PER STATION		15			77	
NO. OF INDIVIDUALS PER STATION		31			10442*	

*INCLUDED IN THIS TOTAL ARE 8080 SPECIMENS OF AMPELISCA AGASSIZI DISTRIBUTED AS FOLLOWS:

#1	#2	#3
1954	3390	2736

TABLE 17 A

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION BRENTON REEF DUMP SITE DATE 25 APRIL 1978

PREDOMINANT SPECIES	DREDGE 1	NUMBER 2	3	TOTAL	MEAN	STD DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1. Ninoe nigrippes	6	0	3	9	3.0	3.0	3.0	0-10.5	1	30.0	30.0
2. *Scalibregma inflatum*	4	0	0	4	1.3	2.3	4.1	0- 7.0	2	13.3	43.3
3. Unciola irrorata	2	0	2	4	1.3	1.2	1.0	0- 4.3	2	13.3	56.6
4. Nucula proxima	0	0	2	2	0.7	1.2	1.9	0- 3.7	3	6.7	63.3
5. Spisula *solidissima*	0	0	2	2	0.7	1.2	1.9	0- 3.7	3	6.7	70.0
6. Cerianthus sp.	0	0	1	1	0.3	0.6	1.1	0- 1.8	4	3.3	73.3
7. Rynchocoela sp.	1	0	0	1	0.3	0.6	1.1	0- 1.8	4	3.3	76.6
8. *Ampharete arctica*	0	1	0	1	0.3	0.6	1.1	0- 1.8	4	3.3	79.9
9. Lumbriclymene cylindricauda	0	0	1	1	0.3	0.6	1.1	0- 1.8	4	3.3	83.2
10. Nephthys incisa	1	0	0	1	0.3	0.6	1.1	0- 1.8	4	3.3	86.5
11. Nephthys sp.	0	1	0	1	0.3	0.6	1.1	0- 1.8	4	3.3	89.8
12. Polycirrus sp.	1	0	0	1	0.3	0.6	1.1	0- 1.8	4	3.3	93.1
13. Byblis serrata	1	0	0	1	0.3	0.6	1.1	0- 1.8	4	3.3	96.4
14. Cancer irroratus	1	0	0	1	0.3	0.6	1.1	0- 1.8	4	3.3	99.7
15.											
16.											
17.											
18.											
TOTAL	17	2	11	30	10.0	7.6	5.7	0-28.9			
TOTAL NO. OF SPP. PER DREDGE	9	2	6	15	5.7	3.5		0-14.4			
SPECIES DIVERSITY (H')	1.91	0.69	1.72	4.32	1.44	0.66					
EQUITABILITY (J')	0.87	1.00	0.96	2.83	0.94	0.07					

TOTAL NO. OF INDIVIDUALS THIS STN = 30
(CORRECTED FOR ONE NEMATODE)

TABLE 17 B

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION BRENTON REEF REFERENCE STN DATE 19 APRIL 1978

PREDOMINANT SPECIES	DREDGE NUMBER 1	2	3	TOTAL	MEAN	STD DEVIATION	CEOFF. OF DISPERSION	95 PERCENT CONF.LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1. Ampharete acutifrons	163	240	211	614	204.7	38.9	7.4	108.1-301.3	1	26.0	26.0
2. Chone infundibuliformis	74	122	157	353	117.7	41.7	14.8	14.1-221.3	2	14.9	40.9
3. Unciola irrorata	75	185	90	350	116.7	59.7	30.5	0-265.0	3	14.8	55.7
4. Leptocheirus pinguis	0	182	107	289	96.3	91.5	86.9	0-323.6	4	12.2	67.9
5. Ninoe nigripes	46	65	63	174	58.0	10.4	1.9	32.2- 83.8	5	7.4	75.3
6. Eudorella emarginata	16	32	22	70	23.3	8.1	2.8	0- 28.2	6	3.0	78.3
7. Pherusa affinis	22	23	19	64	21.3	2.1	0.2	16.1- 26.5	7	2.7	81.0
8. Scalibregma inflatum	14	20	14	48	16.0	3.5	0.8	7.3- 24.7	8	2.0	83.0
9.											
10.											
11.											
12.											
13.											
14.											
15.											
16.											
17.											
18.											
TOTAL	410	869	683	1962	654.0	230.9	81.5	71.4-1227.6			
TOTAL NO. OF SPP. PER DREDGE	40	48	49	77	45.7	4.9	0.5	33.5-57.9			
SPECIES DIVERSITY (H')	1.04	1.08	1.13	3.25	1.08	0.05					
EQUITABILITY (J')	0.28	0.28	0.29	0.85	0.85	0.28	0.01				

TOTAL NO. OF INDIVIDUALS THIS STN = 8080
(CORRECTED FOR AMPELISCA AGASSIZI)

TABLE 18

DAMOS DATA SUMMARY - TOTAL DISTRIBUTION

SPRING COLLECTIONS - 1978

STATION	MEAN NO. SPECIES	STD DEV	95% CONF INTERVALS	MEAN NO. INDIVIDUALS	STD DEV	95% CONF INTERVALS	NO. OF SAMPLES
RHODE ISLAND BIGHT							
BRENTON REEF DUMP SITE	5.7	3.5	0-14.4	10.3	8.0	0-30.2	3
BRENTON REEF REFERENCE	45.7	4.9	33.5-57.9	3480.7	959.0	1098-5863	3

TABLE 19

MASTER SPECIES LIST - Long Island Sound Stations

Species	Occurrence/ 26 Samples	No. Individuals
Phylum PROTOZOA		
1. Foraminifira	1	2
Phylum PORIFERA		
2. PORIFERA sp.	1	1
Phylum CNIDARIA		
Cl. Hydrozoa		
3. Calycella syringa	4	4+
4. Campanularia (flexuosa)	3	3+
5. Campanularia (verticillata)	2	2+
6. Campanularia sp.	5	5+
7. Corymorpha pendula	7	13
8. Halecium sp.	3	3+
9. Sertularia sp.	1	1+
10. Stylactis hooperi	4	10
11. Thuiaria (cupressina)	6	6+
12. Thuiaria (fabricii)	1	1+
13. Thuiaria sp.	2	2+
Cl. Anthozoa		
14. ACTINIARIA sp (developing)	2	23
15. ANTHOZOAN sp. (developing)	1	5
16. Cerianthus sp.	8	17
17. Edwardsia (elegans)	3	1
18. Halcampoides sp.	1	1
Phylum RYNCHOCOELA		
19. Amphiporus sp.	1	1
20. Cerebratulus sp.	3	5
21. Micrura sp.	3	4
22. RYNCHOCOELA sp.	1	1
Phylum NEMATODA		
23. NEMATODA sp.	1	35
Phylum MOLLUSCA		
Cl. Gastropoda		
24. Anachis lafresnayi	4	11
25. Crepidula fornicata	1	1
26. Crepidula plana	2	9
27. Lunatia heros	1	1
28. Lunatia triseriata	3	3
29. Mitrella lunata	2	7
30. Nassarius trivittatus	12	37
31. Polinices duplicatus	1	5
32. Polinices sp.	1	1
33. Urosalpinx cinerea	1	1
Cl. Pelecypoda		

Species	Occurrence/ 26 Samples	No. Individuals
34. Astarte undata	1	1
35. Astarte (undata)	3	6
36. Cerastoderma pinnulatum	2	3
37. Cyclocardia borealis	5	11
38. Dacrydium vitreum	1	16
39. Macoma tenta	1	1
40. Macoma sp.	1	3
41. Modiolus modiolus	2	2
42. Mulinia lateralis	4	4
43. Musculus niger	2	3
44. Mytilus edulis	4	231
45. Nucula proxima	9	21
46. Periploma fragile	2	2
47. Pitar morrhuana	10	21
48. Solemya velum	1	1
49. Spisula solidissima	1	2
50. Tellina agilis	1	2
51. Tellina versicolor	2	4
52. Thyasira sp.	1	1
53. Yoldia limatula	4	9
54. Yoldia lucida	1	1
Phylum ANNELIDA		
Cl. Polychaeta		
55. Ampharete acutifrons	4	16
56. Ampharete arctica	1	5
57. Autolytus cornutus	2	141
58. Autolytus sp.	1	1
59. Caulleriella fillariensis	1	1
60. CIRRATULID sp.	4	9
61. Clymenella zonalis	4	6
62. CLYMENELLINAE sp.	1	1
63. Euclymene collaris	6	53
64. Glycera americana	8	8
65. Harmathoe imbricata	2	5
66. HESIONID sp.	1	1
67. Loimia medusa	6	19
68. Lumbrineris fragilis	3	3
69. Lumbrineris tenuis	4	7
70. MALDANID sp.	1	1
71. Maldanopsis elongata	2	2
72. Melinna cristata	5	6
73. Microphthalmus abberans	1	2
74. Nephthys incisa	19	254
75. Nephthys picta	2	2
76. Nereis succinea	1	1
77. Nereis zonata	2	2
78. Ninoe nigrippes	6	71
79. Notocirrus spiniferus	1	1
80. Ophioglycera gigantea	1	1

Species	Occurrence/ 26 Samples	No. Individuals
81. Owenia fusiformis	3	11
82. Pectinaria (gouldii)	5	9
83. Pherusa affinis	16	40
84. Polycirrus sp.	2	4
85. Polydora ciliata	1	2
86. Polydora gracilis	1	1
87. Polydora sp.	1	1
88. Potamilla reniformis	3	21
89. Sabellaria vulgaris	3	3
90. Scalibregma inflatum	4	22
91. Scoloplos fragilis	1	1
92. Spio (filicornis)	1	1
93. Sthenalais boa	2	2
94. TEREBELLID sp.	2	5
Phylum SIPUNCULIDA		
95. Phascolion strombi	2	2
Phylum ARTHROPODA		
Cl. Crustacea		
Subcl. Cirripedia		
96. Balauus balauus	1	2
97. Balauus crenatus	1	18
Subcl. Ostracoda		
98. Pseudocytheretta (edwardsii)	1	1
Subcl. Copepoda		
99. Calauus sp.	2	4
100. CYCLOPOID sp.	1	12
O. Isopoda		
101. Idotea phosphorea	1	1
O. Amphipoda		
102. Aeginina sp.	1	3
103. Ampelisca abdita	1	4
104. Ampelisca agassizi	1	1
105. Ampelisca vadorum	4	654
106. Corophium crassicorne	1	1
107. Dulichia porrecta	1	2
108. Erichthonius rubricornis	1	6
109. Harpinia propinqua	1	1
110. Leptocheirus pinguis	3	3
111. Maera danae	2	2
112. Parametopella cypris	1	17
113. Photis dentata	1	4
114. Phoxocephalus holbolli	3	10
115. Stenopleustes gracilis	1	2
116. Stenothoe minuta	1	22
117. Unciola irrorata	10	45
O. Decapoda		
118. Cancer irroratus	3	6
119. Eurypanopeus depressus	1	1

Species	Occurrence/ 26 Samples	No. Individuals
120. Hexapanopeus angustifrons	3	8
121. Libinia emarginata	3	3
122. Pagurus longicarpus	7	12
123. Pagurus pollicaris	1	1
124. Upogebia affinis	1	6
Phylum BRYOZOA		
125. Aeverrillia (armata)	1	1+
126. Aetea sp.	1	1+
127. Bicellariella cilata	2	2+
128. Bowerbankia sp.	2	2+
129. Callopora aurita	3	3+
130. Callopora craticula	1	1+
131. Hippoporina sp.	3	3+
132. Hippothoa hyalina	2	2+
133. Membranipora tenuis	3	3+
134. Schizoporella unicornis	1	1+
135. SCRUPARIID sp.	1	1+
136. Triticella sp.	4	4+
Phylum ECHINODERMATA		
Cl. Holothuroidea		
137. APODIDA sp.	1	1
Cl. Stelleroidea		
138. Amphipholis squamata	1	2
139. Asterias forbesii	1	1
Cl. Echinoidea		
140. Echinarachnius parma	1	3

TABLE 20

DAMOS DATA SUMMARY - TOTAL DISTRIBUTION - LONG ISLAND SOUND STATIONS

WINTER - SPRING COLLECTIONS 1978

TOTAL # PHYLA: 11

TOTAL # SPECIES: 140

TOTAL NO. INDIVIDUALS: 2,190

PREDOMINANT SPECIES LIST

	SPECIES	PHYLA	FEEDING TYPE	OCCURRENCE/ 26 SAMPLES	TOTAL # INDIVIDUALS	% TOTALS	CUMUL %
1.	Ampelisca vadorum	AR	SF	4	654	29.8	29.8
2.	Nephthys incisa	A	DF	19	254	11.6	41.4
3.	Mytilus edulis	M	SF	4	231	10.5	51.9
4.	Autolytus cornutus	A	C	2	141	6.4	58.3
5.	Ninoe nigrippes	A	C	6	71	3.2	61.5
6.	Euclymene collaris	A	DF	6	53	2.4	63.9
7.	Unciola irrorata	AR	DF	10	45	2.1	66.0
8.	Pherusa affinis	A	DF	16	40	1.8	67.8

A: ANNELIDA
AR: ARTHROPODA
M: MOLLUSCA
SF: SUSPENSION FEEDER
DF: DEPOSIT FEEDER
C: CARNIVOROUS

TABLE 21

DAMOS DATA SUMMARY - TOTAL DISTRIBUTION - LONG ISLAND SOUND

WINTER - SPRING COLLECTIONS - 1978 EASTERN STATIONS

	NEW LONDON DUMPSITE			NEW LONDON REFERENCE			CORNFIELD SHOAL DUMPSITE		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No. Of Species Per Sample	6	30	46	45	40	34	1	2	2
No. Of Individuals Per Sample	12	75	766	279	131	91	1	2	6
No. Of Phyla Per Station		8			8			2	
No. Of Species Per Station		60			75			5	
No. Of Individuals Per Station		853			501			9	

	CORNFIELD SHOAL REFERENCE			NEW HAVEN DUMPSITE			NEW HAVEN REFERENCE		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No. Of Species Per Sample	0	2	18	13	17	26	13	15	16
No. Of Individuals Per Sample	0	15	74	68	55	348	36	59	31
No. Of Phyla Per Station		6			9			6	
No. Of Species Per Station		18			37			28	
No. Of Individuals Per Station		89			471			126	

	CABLE & ANCHOR REEF DUMPSITE			WESTERN L.I.S. DUMPSITE			CAR & WLIS REFERENCE		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No. Of Species Per Sample	6	7	2	4	6	2	5	6	7
No. Of Individuals Per Sample	17	20	8	6	11	2	30	18	31
No. Of Phyla Per Station		4			3			4	
No. Of Species Per Station		11			9			13	
No. Of Individuals Per Station		45			19			79	

TABLE 22 A

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

NEW LONDON DUMP SITE - 17 APRIL 1978

	PREDOMINANT SPECIES	DREDGE NUMBER #1	#2	#3	TOTAL	MEAN	STANDARD DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL: % OF TOTAL
1.	Ninoe nigrippes	7	13	20	40	13.3	6.5	3.2	0-29.4	1	18.3	18.3
2.	Unciola irrorata	0	6	16	22	7.3	8.1	9.0	0-27.4	2	10.1	28.4
3.	Potamilla reniformis	0	0	19	19	6.3	11.0	19.1	0-33.6	3	8.7	37.1
4.	Scalibregma inflatum	0	4	14	18	6.0	7.2	8.7	0-23.9	4	8.3	45.4
5.	Pitar morrhuana	1	1	6	8	2.7	2.9	3.1	0- 9.9	5	3.7	49.1
6.	Pherusa affinia	0	2	6	8	2.7	3.1	3.5	0-10.4	5	3.7	52.8
7.	Cyclocardia borealis	1	2	3	6	2.0	1.0	0.5	0- 4.5	6	2.8	55.6
8.	Nucula proxima	0	2	3	5	1.7	1.5	1.4	0- 5.4	7	2.3	57.9
9.	Ampharete acutifrons	0	1	4	5	1.7	2.1	2.5	0- 6.9	7	2.3	60.2
10.	Nephthys incisa	1	0	4	5	1.7	2.1	2.5	0- 6.9	7	2.3	62.5
11.	Cancer irroratus	0	2	3	5	1.7	1.5	1.4	0- 5.4	7	2.3	64.8
12.	Sylactis hooperi	0	2	2	4	1.3	1.2	1.0	0- 4.3	8	1.8	66.6
13.	Astarte (undata)	1	0	3	4	1.3	1.5	1.8	0- 5.0	8	1.8	68.4
14.	Ampelisca abdita	0	0	4	4	1.3	2.3	4.1	0- 7.0	8	1.8	70.2
15.	Photis dentata	0	0	4	4	1.3	2.3	4.1	0- 7.0	8	1.8	72.0
16.	Phoxocephalus holbolli	0	0	4	4	1.3	2.3	4.1	0- 7.0	8	1.8	73.8
17.	Pagurus longicarpus	1	1	2	4	1.3	0.6	0.3	0- 2.8	8	1.8	75.6
TOTAL		12	36	117	165	55.0	55.0	55.0	0-191.6			
TOTAL # OF SPP PER DREDGE		6	30	46	60	27.3	20.1		0- 77.2			
SPECIES DIVERSITY (H')		1.35	2.40	1.12	4.87	1.62	0.68					
EQUITABILITY (J')		0.75	0.75	0.29	1.79	0.60	0.27					

TOTAL # OF INDIVIDUALS THIS STATION = 218
(Corrected for 635 specimens of A. Vadorum)

TABLE 22 B

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

NEW LONDON REFERENCE STATION - 17 APRIL 1978

PREDOMINANT SPECIES	DREDGE NUMBER #1	#2	#3	TOTAL	MEAN	STANDARD DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL: % OF TOTAL
1. Mytilis edulis	164	19	30	213	71.0	80.7	91.8	0-271.5	1	42.5	42.5
2. Euclymene collaris	17	20	10	47	15.7	5.1	1.7	3.0-28.4	2	9.4	51.9
3. Ninoe nigrippes	7	17	7	31	10.3	5.8	3.2	0- 24.7	3	6.2	58.1
4. Ampelisca vadorum	10	9	0	19	6.3	5.5	4.8	0- 20.0	4	3.8	61.9
5. Ampharete acutifrons	0	7	4	11	3.7	3.5	3.3	0- 12.4	5	2.2	64.1
6. Pherusa affinis	3	2	5	10	3.3	1.5	0.7	0- 7.0	6	2.0	66.1
7. Unciola irroratus	5	3	2	10	3.3	1.5	0.7	0- 7.0	6	2.0	68.1
8. Nassarius trivittatus	5	4	0	9	3.0	2.6	2.3	0- 9.5	7	1.8	69.9
9. Pitar morrhuana	2	5	2	9	3.0	1.7	1.0	0- 7.2	7	1.8	71.7
TOTAL	213	86	60	359	119.7	81.9	56.0	0-323.2			
TOTAL # OF SPP PER DREDGE	45	40	34	75	39.7	5.5		26.0-53.4			
SPECIES DIVERSITY (H')	2.07	3.06	2.73	7.86	2.62	0.50					
EQUITABILITY (J')	0.54	0.83			0.71	0.15					

TOTAL # OF INDIVIDUALS THIS STATION = 501

TABLE 22 C

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

CORNFIELD SHOAL DUMP SITE - 31 JANUARY 1978

PREDOMINANT SPECIES	DREDGE NUMBER #1	#2	#3	TOTAL	MEAN	STANDARD DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL: % OF TOTAL
1. Anthozoan sp.	0	0	5	5	1.7	2.9	4.9	0-8.9	1	55.6	55.6
2. Anachis lafresnayi	0	1	0	1	0.3	0.6	1.1	0-1.8	2	11.1	66.7
3. Lunatia heros	1	0	0	1	0.3	0.6	1.1	0-1.8	2	11.1	77.8
4. Nassarius trivittatus	0	0	1	1	0.3	0.6	1.1	0-1.8	2	11.1	88.9
5. Urosalpinx cinerea	0	1	0	1	0.3	0.6	1.1	0-1.8	2	11.1	100.0
TOTAL	1	2	6	9	3.0	2.6	2.3	0-9.5			
TOTAL # OF SPP PER DREDGE	1	2	2	5	1.7	0.6		0.2-3.2			
SPECIES DIVERSITY (H')	0	0.69	0.45	1.14	0.38	0.35					
EQUITABILITY (J')	0	1.00	0.65	1.65	0.55	0.51					

TOTAL # OF INDIVIDUALS THIS STATION = 9

TABLE 22 D

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

CORNFIELD SHOAL REFERENCE STATION - 31 JANUARY 1978

PREDOMINANT SPECIES	DREDGE NUMBER #1	#2	#3	TOTAL	MEAN	STANDARD DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL: % OF TOTAL
1. Mytilus edulis	0	0	18	18	6.0	10.4	18.0	0-31.8	1	20.2	20.2
2. Nassarius trivittatus	0	12	5	17	5.7	6.0	6.4	0-20.6	2	19.1	39.3
3. Anachis lafresnayi	0	0	7	7	2.3	4.0	7.1	0-12.2	3	7.9	47.2
4. Crepidula plana	0	0	5	5	1.7	2.9	4.9	0- 8.9	4	5.6	52.8
5. Pherusa affinis	0	0	3	3	1.0	1.7	3.0	0- 5.2	5	3.4	56.2
6. Pagurus longicornis	0	0	3	3	1.0	1.7	3.0	0- 5.2	5	3.4	59.6
7. Echinarachnius parma	0	3	0	3	1.0	1.7	3.0	0- 5.2	5	3.4	63.0
8. Tellina agilis	0	0	2	2	0.7	1.2	1.9	0- 3.7	6	2.2	65.2
9. Unicola irrorata	0	0	2	2	0.7	1.2	1.9	0- 3.7	6	2.2	67.4
10. Amphipolis squamata	0	0	2	2	0.7	1.2	1.9	0- 3.7	6	2.2	69.6
TOTAL	0	15	47	62	20.7	24.0	27.8	0-80.3			
TOTAL # OF SPP PER DREDGE	0	2	18	18	6.7	9.9		0-31.2			
SPECIES DIVERSITY (H')	0	0.50	2.33	2.83	0.94	1.23					
EQUITABILITY (J')	0	0.72	0.81	1.53	0.51	0.44					

TOTAL # OF INDIVIDUALS THIS STATION = 89

TABLE 22 E

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

NEW HAVEN DUMP SITE - 13 APRIL 1978

	PREDOMINANT SPECIES	DREDGE NUMBER #1	#2	#3	TOTAL	MEAN	STANDARD DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL: % OF TOTAL
1.	Autolytus cornutus	0	0	139	139	46.3	80.3	139.1	0-245.8	1	32.7	32.7
2.	Nephthys incisa	40	13	49	102	34.0	18.7	10.3	0- 80.5	2	24.0	56.7
3.	Actiniaria sp.	0	0	22	22	7.3	12.7	22.1	0- 38.9	3	5.2	61.9
4.	Stenothoe minuta	0	0	22	22	7.3	9.8	22.1	0- 38.9	3	5.2	67.1
5.	Parametopella cypris	0	0	17	17	5.7	9.2	16.9	0- 30.0	4	4.0	71.1
6.	Dacrydium vitreum	0	0	16	16	5.3	4.4	16.1	0- 28.2	5	3.8	74.9
7.	Loimia medusa	3	10	2	15	5.0	4.0	3.8	0- 15.9	6	3.5	78.4
8.	Unciola irrorata	8	1	1	10	3.3	3.1	4.9	0- 13.2	7	2.4	80.8
9.	Owenia fusiformis	0	6	2	8	2.7	1.5	3.5	0- 10.4	8	1.9	82.7
10.	Hexapanopeus angustifrons	1	3	4	8	2.7		0.9	0- 6.4	8	1.9	84.6
	TOTAL	52	33	274	359	119.7	134.0	150.0	0-452.6			
	TOTAL # OF SPP PER DREDGE	13	17	26	37	18.7	6.7		2.2-35.2			
	SPECIES DIVERSITY (H')	1.59	2.40	2.14	6.13	2.04	0.41					
	EQUITABILITY (J')	0.62	0.85	0.66	21.3	0.71	0.12					

TOTAL # OF INDIVIDUALS THIS STATION = 425
(Corrected for nematode and cyclopoid SPP)

TABLE 22 F

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

STATION NEW HAVEN REFERENCE STN DATE 13 APRIL 1978

PREDOMINANT SPECIES	DREDGE NUMBER 1	2	3	TOTAL	MEAN	STD DEVIATION	COEFF.OF DISPERSION	95 PERCENT CONF.LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL. % OF TOTAL
1. Nephthys incisa	12	32	7	51	17.0	13.2	10.3	0-49.8	1	41.8	41.8
2. Cerianthus sp.	2	2	5	9	3.0	1.7	1.0	0- 7.2	2	7.4	49.2
3. Pherusa affinis	3	2	2	7	2.3	0.6	0.1	0.8- 3.8	3	5.7	54.9
4. Corymorpha pendula	4	1	1	6	2.0	1.7	1.5	0- 6.2	4	4.9	59.8
5. Yoldia limatula	3	3	0	6	2.0	1.7	1.5	0- 6.2	4	4.9	64.7
6. Polinices duplicatus	0	5	0	5	1.7	2.9	4.9	0- 8.9	5	4.1	68.8
7. Nucula proxima	2	1	2	5	1.7	0.6	0.2	0.2- 3.2	5	4.1	72.9
8. Pectinaria (gouldu)	0	4	0	4	1.3	2.3	4.1	0- 7.0	6	3.3	76.2
9. Cerebratulus sp.	0	3	0	3	1.0	1.7	3.0	0- 5.2	7	2.5	78.7
10. Loimia medusa	0	1	2	3	1.0	1.0	1.0	0- 3.5	7	2.5	81.2
11. Melinna cristata	1	1	1	3	1.0	0.0	0.0	1.0	7	2.5	83.7
12. Owenia fusiformis	0	0	3	3	1.0	1.7	3.0	0- 5.2	7	2.5	86.2
13. Nassarius trivittatus	2	0	0	2	0.7	1.2	1.9	0- 3.7	8	1.6	87.8
14. Mulinia lateralis	1	0	1	2	0.7	0.6	0.5	0- 2.2	8	1.6	89.4
15.											
16.											
17.											
18.											
TOTAL	30	55	24	109	36.3	16.4	7.5	0-77.0			
TOTAL NO. OF SPP. PER DREDGE	13	15	16	28	14.7	1.5		10.9-18.5			
SPECIES DIVERSITY (H')	2.21	1.81	2.49	6.51	2.17	0.34					
EQUITABILITY (J')	0.86	0.67	0.90	2.43	0.81	0.12					

TOTAL NO. OF INDIVIDUALS THIS STN = 122
(CORRECTED FOR CALANUS SP)

TABLE 22 G

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

CAR DUMP SITE - 11 APRIL 1978

PREDOMINANT SPECIES	DREDGE NUMBER #1	#2	#3	TOTAL	MEAN	STANDARD DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL: % OF TOTAL
1. Nephthys incisa	6	14	7	27	9.0	4.4	2.1	0-15.3	1	60.0	60.0
2. Nucula proxima	6	0	0	6	2.0	3.5	6.0	0-10.7	2	13.3	73.3
3. Nassarius trivittatus	0	1	1	2	0.7	0.6	0.5	0- 2.2	3	4.4	77.7
4. Pitar morrhuana	1	1	0	2	0.7	0.6	0.5	0- 2.2	3	4.4	82.1
5. Yoldia limatula	2	0	0	2	0.7	1.2	1.9	0- 3.7	3	4.4	86.5
6. Thuiaria sp.	0	1	0	1	0.3	0.6	1.1	0- 1.8	4	2.2	88.7
7. Cerianthus sp.	0	1	0	1	0.3	0.6	1.1	0- 1.8	4	2.2	90.9
8. Cerebratulus sp.	0	1	0	1	0.3	0.6	1.1	0- 1.8	4	2.2	93.1
9. Mulinia lateralis	1	0	0	1	0.3	0.6	1.1	0- 1.8	4	2.2	95.3
10. Lumbrineris fragilis	1	0	0	1	0.3	0.6	1.1	0- 1.8	4	2.2	97.5
11. Pectinaria (gouldii)	0	1	0	1	0.3	0.6	1.1	0- 1.8	4	2.2	99.7
TOTAL	17	20	8	45	15.0	6.2	2.6	0-30.4			
TOTAL # OF SPP PER DREDGE	6	7	2	11	5.0	2.6		0-11.6			
SPECIES DIVERSITY (H')	1.49	1.15	0.38	3.02	1.01	0.57					
EQUITABILITY (J')	0.83	0.59	0.54	1.96	0.65	0.16					

TOTAL # OF INDIVIDUALS THIS STATION = 45

TABLE 22 H

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

WLIS DUMP SITE - 12 APRIL 1978

PREDOMINANT SPECIES	DREDGE NUMBER #1	#2	#3	TOTAL	MEAN	STANDARD DEVIATION	COEFF. OF DISPERSION	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL: % OF TOTAL
1. Nephythys incisa	2	6	1	9	3.0	2.6	2.3	0-9.5	1	47.4	47.4
2. Pherusa affinis	2	1	0	3	1.0	1.0	1.0	0-3.5	2	15.8	63.2
3. Corymorpha pendula	0	0	1	1	0.3	0.6	1.1	0-1.8	3	5.3	68.5
4. Cerianthus sp.	1	0	0	1	0.3	0.6	1.1	0-1.8	3	5.3	73.8
5. Nassarius trivittatus	0	1	0	1	0.3	0.6	1.1	0-1.8	3	5.3	79.1
6. Pitar morrhuana	0	1	0	1	0.3	0.6	1.1	0-1.8	3	5.3	84.4
7. Glycera americana	0	1	0	1	0.3	0.6	1.1	0-1.8	3	5.3	89.7
8. Maldanid sp.	0	1	0	1	0.3	0.6	1.1	0-1.8	3	5.3	95.0
9. Pagurus longicarpus	1	0	0	1	0.3	0.6	1.1	0-1.8	3	5.3	100.0
TOTAL	6	11	2	19	6.3	4.5	3.2	0-17.5			
TOTAL # OF SPP PER DREDGE	4	6	2	9	4.0	2.0		0- 9.0			
SPECIES DIVERSITY (H')	1.33	1.42	0.69	3.44	1.15	0.40					
EQUITABILITY (J')	0.96	0.79	1.00	2.75	0.92	0.11					

TOTAL # OF INDIVIDUALS THIS STATION = 19

TABLE 22 I

DAMOS BENTHOS - TABLE OF NUMERIC DENSITY DATA

CAR & WLIS REFERENCE STATION - 12 APRIL 1978

PREDOMINANT SPECIES	DREDGE NUMBER #1	#2	#3	TOTAL	MEAN	STANDARD DEVIATION	COEFF. OF DISPERSICN	95 PERCENT CONF. LIMITS OF MEAN	NUMERIC RANK	% OF TOTAL	CUMUL: % OF TOTAL
1. Nephythys incisa	26	10	20	56	18.7	8.1	3.5	0-38.8	1	70.9	70.9
2. Euclymene collaris	1	3	0	4	1.3	1.5	1.8	0- 5.0	2	5.1	76.0
3. Nassarius tribittatus	0	0	3	3	1.0	1.7	3.0	0- 5.2	3	3.8	79.8
4. Macoma sp.	0	0	3	3	1.0	1.7	3.0	0- 5.2	3	3.8	83.6
5. Pherusa affinia	0	1	2	3	1.0	1.0	1.0	0- 3.5	3	3.8	87.4
6. Cerianthus sp.	0	2	0	2	0.7	1.2	1.9	0- 3.7	4	2.5	89.9
7. Clymenella zonalis	0	1	1	2	0.7	0.6	0.5	0- 2.2	4	2.5	92.4
TOTAL	27	17	29	73	24.3	6.4	1.7	8.4-40.2			
TOTAL # OF SPP PER DREDGE	5	6	7	13	6.0	1.0		3.5- 8.5			
SPECIES DIVERSITY (H')	0.58	1.35	1.24	3.17	1.06	0.42					
EQUITABILITY (J')	0.36	0.75	0.64	1.75	0.58	0.20					

TOTAL # OF INDIVIDUALS THIS STATION = 79

TABLE 23

DAMOS DATA SUMMARY - TOTAL DISTRIBUTION

WINTER - SPRING COLLECTIONS 1978

STATION	MEAN NO. SPECIES	STANDARD DEVIATION	95% CONF. INTERVALS	MEAN NO. INDIVIDUALS	STANDARD DEVIATION	95% CONF. INTERVALS	NO. OF SAMPLES
			LONG ISLAND SOUND				
NEW LONDON DUMP SITE	27.3	20.1	0-77.2	284.3	418.3	0-1323.6	3
NEW LONDON REFERENCE	39.7	5.5	26.0-53.4	167.0	99.0	0-413.0	3
CORNFIELD SHOAL DUMP SITE	1.7	0.6	0.3- 3.1	3.0	2.7	0- 9.6	3
CORNFIELD SHOAL REFERENCE	6.7	9.9	0-31.2	29.7	39.1	0-126.9	3
NEW HAVEN DUMP SITE	18.7	6.7	2.2-35.2	157.0	165.5	0-568.2	3
NEW HAVEN REFERENCE	14.7	1.5	10.9-18.5	42.0	14.9	4.9-79.1	3
CAR DUMP SITE	5.0	2.6	0-11.6	15.0	6.2	0-30.5	3
WLIS DUMP SITE	4.0	2.0	0- 9.0	6.3	4.5	0-17.5	3
CAR & WLIS REFERENCE	6.0	1.0	3.5-8.5	26.3	7.2	8.3-44.3	3

Table 24

COMPARISON OF GRAB AND DREDGE SAMPLES TAKEN AT THE NEW LONDON REFERENCE SITE

GRAB SAMPLES

	GRAB NUMBER 1	2	3	4	5	TOTAL	MEAN	STANDARD DEVIATION	95% CONF. INTERVALS
MARCH 1977									
# OF SPECIES	36	33	31	28	37	70	33.0	3.7	28.4-37.6
# OF INDIVIDUALS	427	340	340	418	592	2117	423.4	102.9	0-230.7
MARCH 1978									
# OF SPECIES	39	40	36	24	28	68	33.4	7.1	24.9-42.2
# OF INDIVIDUALS	646	354	429	92	131	1652	330.4	227.2	0-509.3

DREDGE SAMPLES

	1	2	3	4	5	TOTAL	MEAN	STANDARD DEVIATION	95% CONF. INTERVALS
MARCH 1978									
# OF SPECIES	45	40	34			75	39.7	5.5	26.0-53.4
# OF INDIVIDUALS	279	131	91			501	167.0	99.0	0-413.0

PROJECTED TOTAL # OF INDIVIDUALS
FOR FIVE DREDGE SAMPLES = 279 + 131 + 91 + 167 + 167 = 835

OF SPECIES COMMON TO BOTH METHODS = 36

TOTAL # OF SPECIES - GRAB & DREDGE COMBINED = 107

% OF SPECIES TOTALS IN GRABS = 64%
% OF SPECIES TOTALS IN DREDGES = 70%

% OF INDIVIDUAL TOTALS IN GRABS = 66%
% OF INDIVIDUAL TOTALS IN DREDGES = 34%

TABLE 25

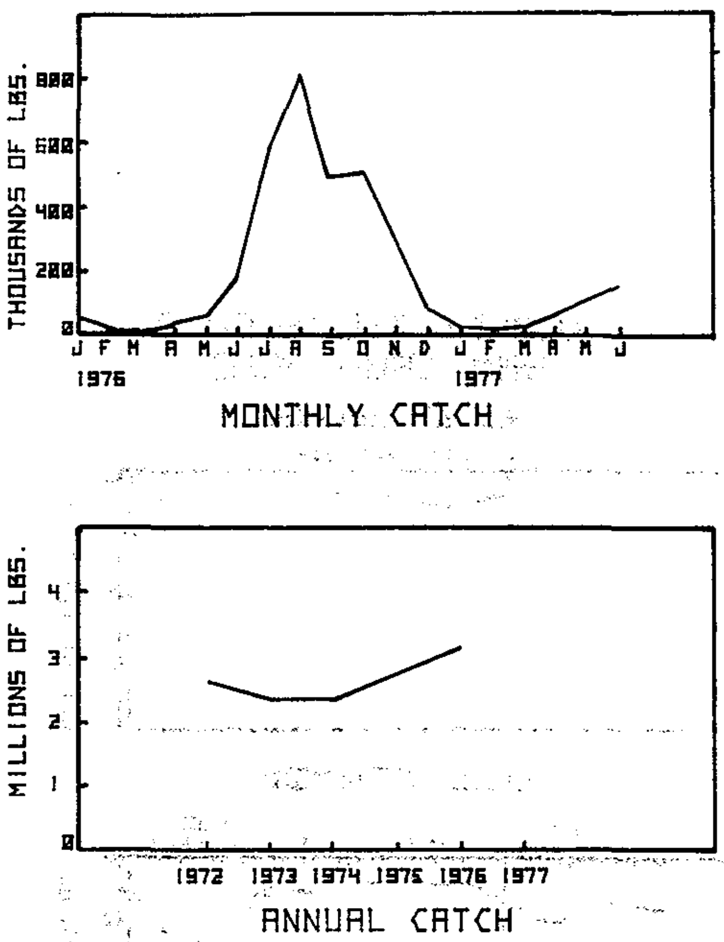
LIFE HISTORY OF NEARSHORE COMMERCIAL FINFISH IN THE GULF OF MAINE (BIGELOW AND SCHROEDER, 1953; TRIGOM, 1976)

SPECIES	DEPTH PREFERENCE (FEET)	FOOD	MOVEMENTS	BREEDING SEASON	EGGS AND LARVAE
Cod - <u>Gadus morrhua</u>	Tide Line - 1500 demersal but will leave btoom	Mollusks, crabs, other btoom invertebrates	Non-migratory, move to spawning grounds, slight inshore-offshore	Late Feb. - late May	Buoyant, eggs 14-30 days 2 months pelagic larvae
Haddack- <u>Melanogrammus aeglefinis</u>	Few less than 30-60, most 150-450 demersal	Varied diet: brittle stars invalves, polychaetes, crabs, squid, sea urchins	Wandering in Gulf of Maine, move to sqawning grounds	Late Feb.- May peak March, April	Buoyant, eggs and larvae Pelagic 3 months
Pollock - <u>Pollachius virens</u>	Surf. - 600 + pelagic	Larger zooplankton esp. enphau siids, fish	Mature wander, move to spawning grounds in southern Gulf of Maine in winter	Nov. - Feb.	Buoyant, 2 months to end of larval period
Whiting - <u>Merluccius bielinearis</u>	Tide line to 900-2400 off shelf in winter epi-pilagic	Shrimp, squid, fish	Migrate offshore in late fall other movements governed by prey and temperature	July-Aug-Sept.	Buoyant, 2 or 3 months to end of larval period
Cusk - <u>Brosme brosme</u>	90-450 around periphery of Gulf, deeper off S. New England - demersal	Crabs, mollusks	No evidence of inshore-offshore movements	Late spring and early summer through July in Gulf	Buoyant

Tb 25 (cont)

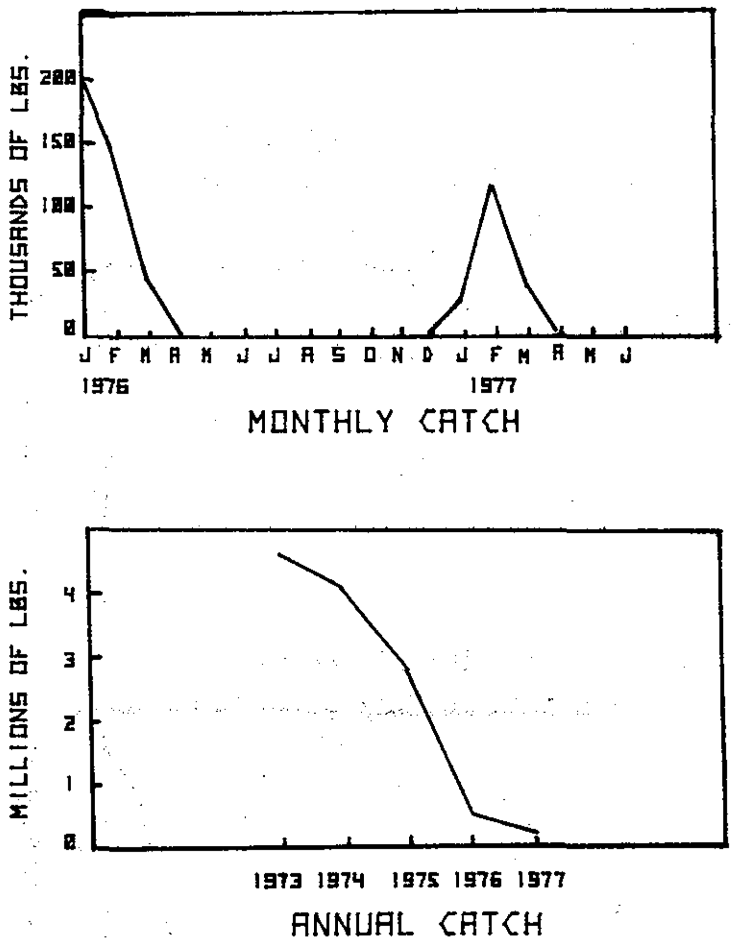
LIFE HISTORY OF NEARSHORE COMMERCIAL FINFISH IN THE GULF OF MAINE (BIGELOW AND SCHROEDER, 1953; TRIGOM, 1976)

SPECIES	DEPTH (PREFERENCE (FEET)	FOOD	MOVEMENTS	BREEDING SEASON	EGGS AND LARVAE
Gray sole - Glyptocephalus cynoglosus (Witch flounder)	Some 60-90 but most 360-900 demersal	Small invertebrates of all types	Stationary	Late spring and summer peak spawning in July-Aug.	Buoyant, long pelagic period up to 4-6 months
American dab-Hippaglossoides platessoides (Canadian plaice)	Tide Line - 2000 + demersal	Invertebrates of all types	Stationary	Peak in May and June	Buoyant, pelagic period 3-4 months
Winter flounder - Pseudopleuronectes americanus (Blackback flounder)	Tide Line - 400 demersal	Small invertebrates of all types especially polychaetes and amphipoda	Young disperse to deeper water	Boothbay peak-April Mass. Bay. Feb.-March 6-33 ft. in bays and estuaries	Demersal in sandy bottom, hatch in 18 days at 37°F
Atlantic herring - Culpea harengus	Pelagic	Copepods and other zooplankton	Juveniles: nearshore, closer in the summer than winter adults	Spawn Aug.-Dec. from north to south on falling water temperature	Demersal, gravel bottoms, in less than 300 ft., larval period 5-8 months, metamorphose close to shore



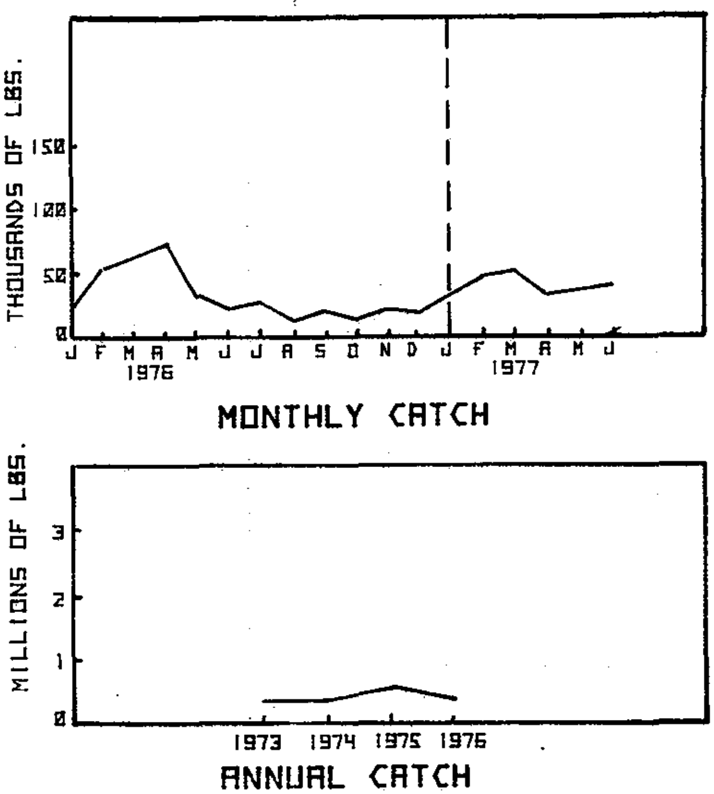
LOBSTER LANDINGS
CUMBERLAND COUNTY

FIG. - 14A



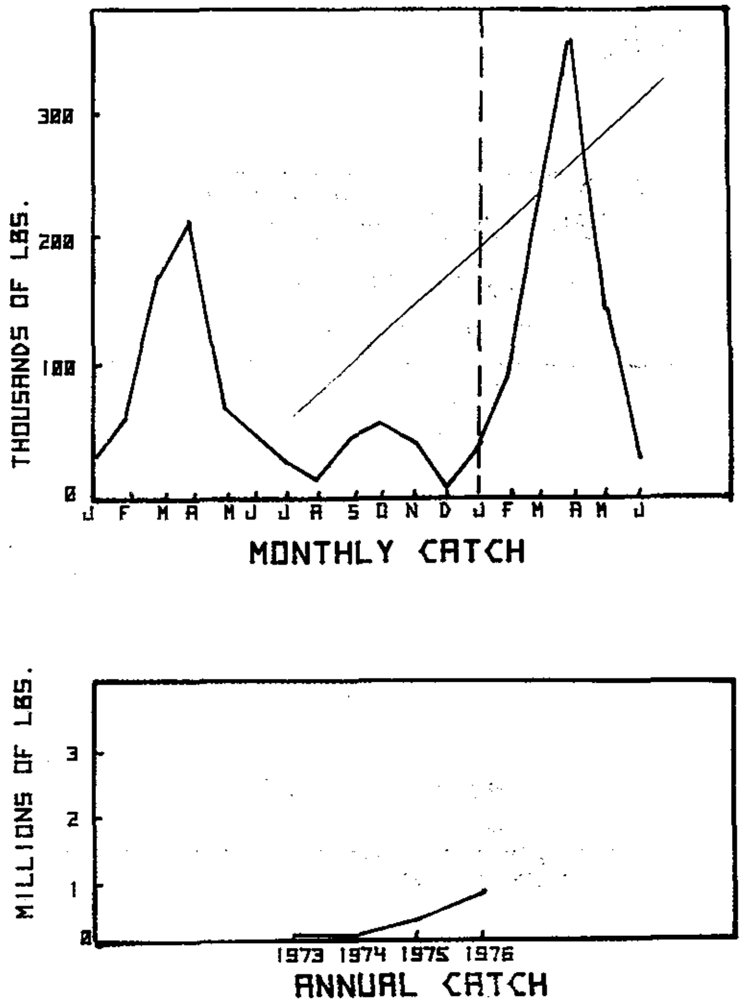
SHRIMP LANDINGS
CUMBERLAND COUNTY

14B



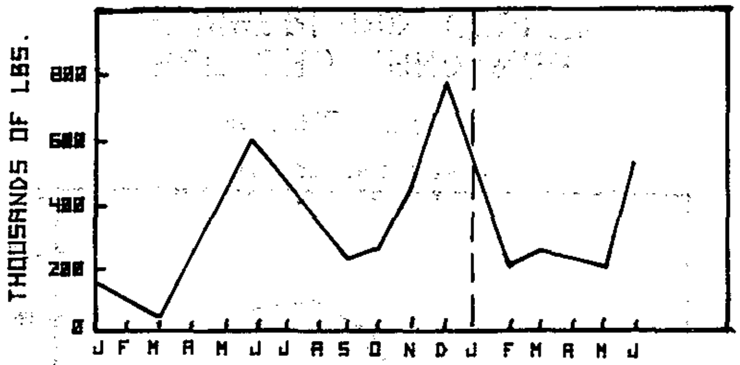
CUSC LANDINGS
CUMBERLAND COUNTY

FIG.-14C

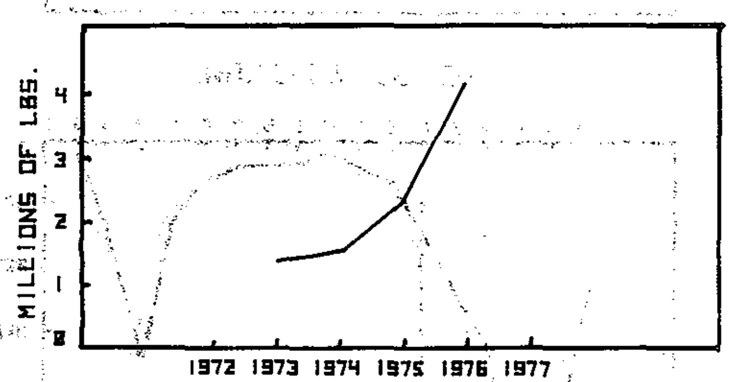


HADDOCK LANDINGS
CUMBERLAND COUNTY

14D



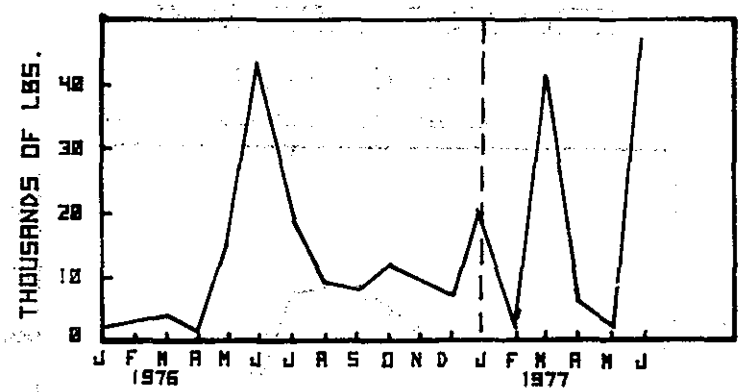
MONTHLY CATCH



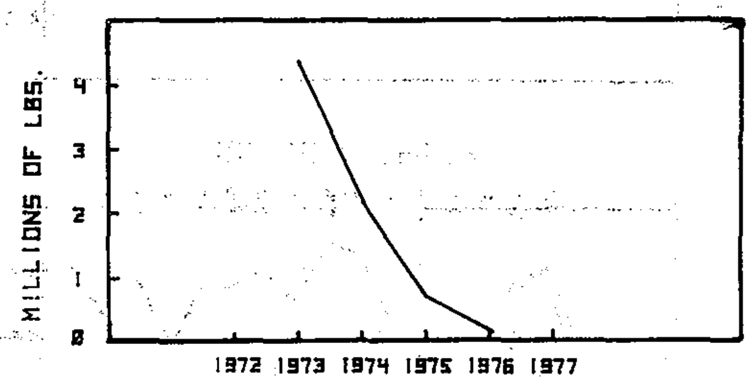
ANNUAL CATCH

POLLOCK LANDINGS
CUMBERLAND COUNTY

FIG.-14E



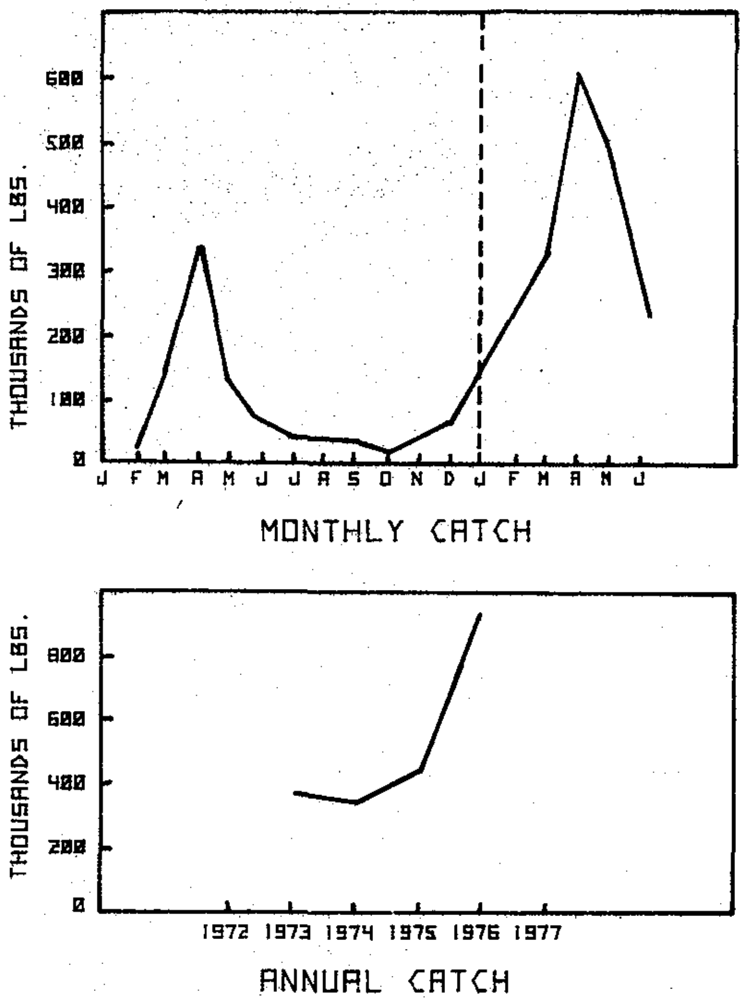
MONTHLY CATCH



ANNUAL CATCH

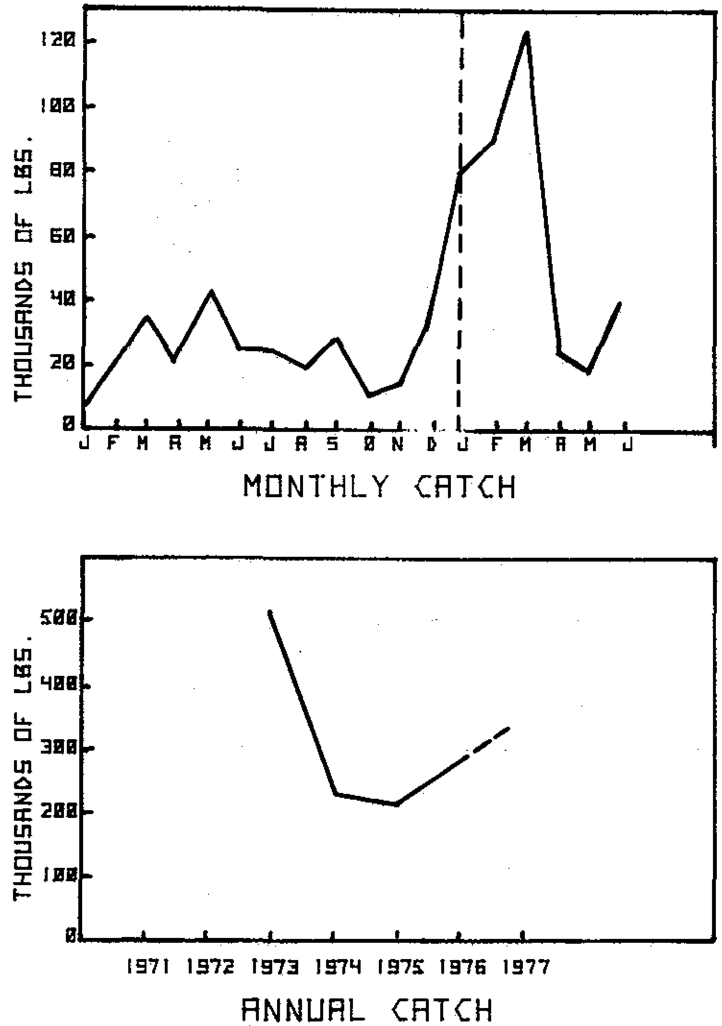
WHITING LANDINGS
CUMBERLAND COUNTY

14 F



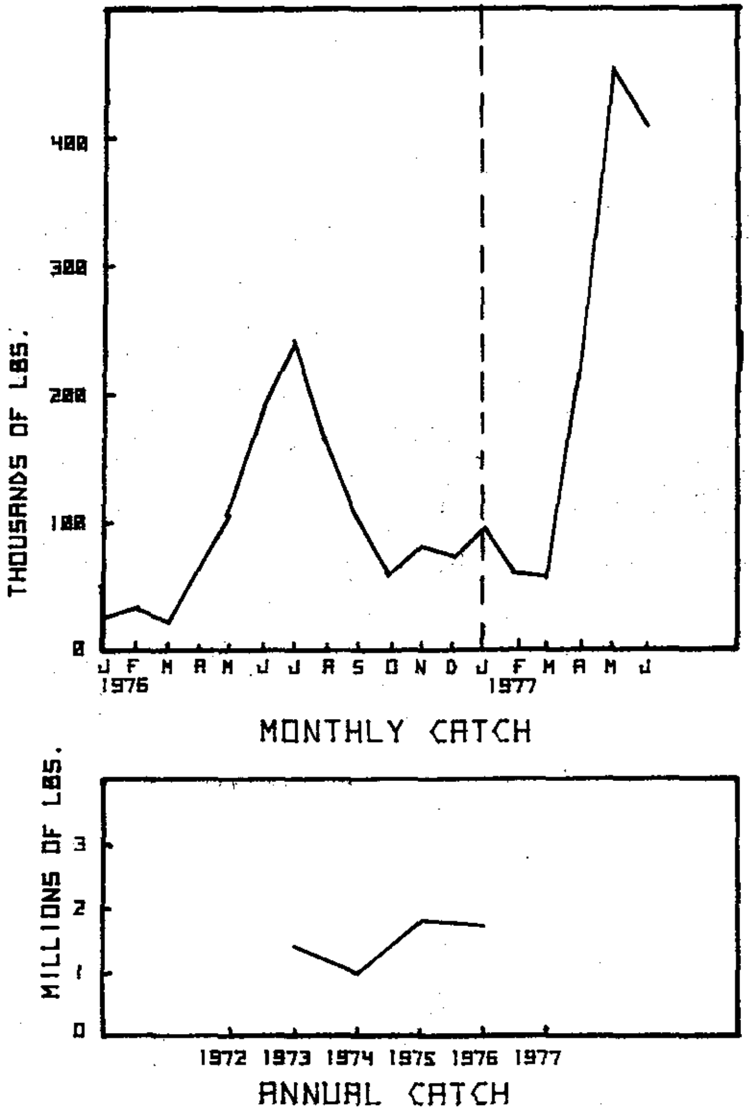
SEA DAB LANDINGS
CUMBERLAND COUNTY

FIG.-14G



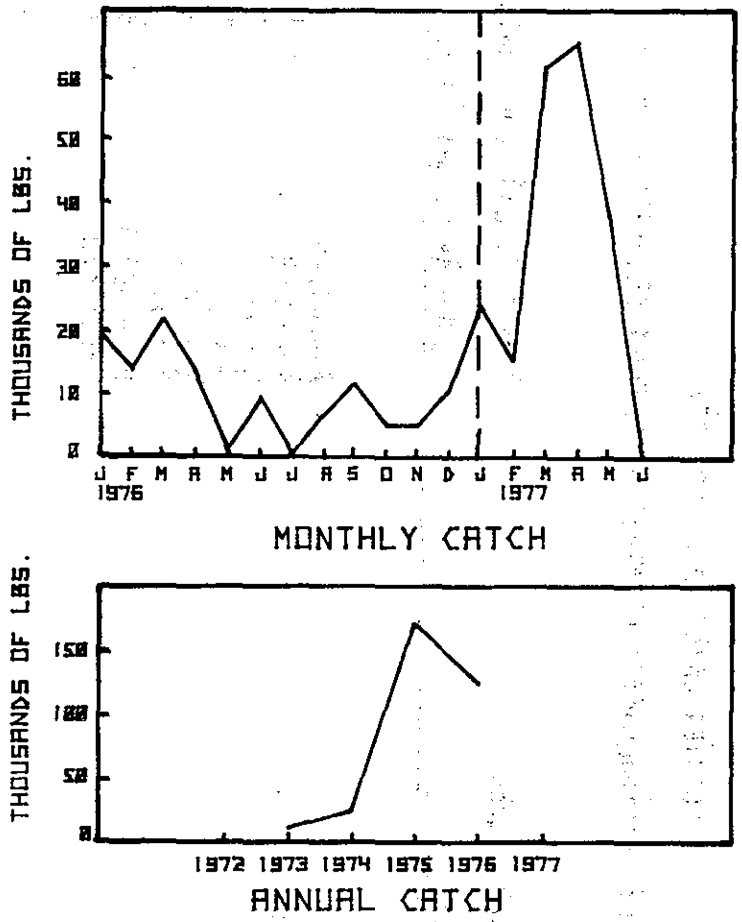
GRAY SOLE LANDINGS
CUMBERLAND COUNTY

14H



COD LANDINGS
CUMBERLAND COUNTY

FIG. - 14 I



BLACKBACK FLOUNDER
LANDINGS
CUMBERLAND COUNTY

14 J

TABLE 26

LOBSTER CATCH DATA FOR 1977

(Conn. Dept. Environmental Protection, Logbook Statistics)

% of N.Y. and Conn. Catch From Areas Within L.I.S.	% of N.Y. and Conn. Catch Landed At Larger Conn. Ports.	
Western Sound	Greenwich	2.3
Conn. 40.81. N.Y. 3.59	Stanford	6.4
	Darien	4.7
	Norwalk	7.1
	Westport	1.3
	Fairfield	0.7
	Bridgeport	10.6
	Stratford	0.2
Central Sound		
Conn. 18.61 N.Y. 0.55	Milford	1.3
	West Haven	0.1
	New Haven	8.3
	East Haven	0.1
	Bramford	3.6
	Gilford	0.7
	Madison	0.3
	Clinton	2.6
	Westbrook	1.7
	Saybrook	0.5
Eastern Sound		
Conn. 8.15 N.Y. 21.77	Old Lyne	0.2
	Waterford	0.7
	New London	0.6
	Groton	16.0
	Noank	1.1
	Stonington	6.5

TABLE 27A

SAMPLE LOCATIONS

SITE: Rockland, Me.

DATE	DISPOSAL SITE: CURRENT METER	MUSSELS	BENTHIC SAMPLES DREDGES	GRABS	REFERENCE SITE MUSSELS	BENTHIC SAMPLES DREDGES	GRABS
12/Dec/1977	44°07'02.5" + 69°00'18.2"		44°07'15.5" 69°00'08.3"				
11/May/1978			44°08'06" 69°00'30"				
13/May/1978		44°07'18.2" 69°00'05.1"		44°07'40.3" 69°00'03.6"	44°06'12" 68°57'15"		Rock. Harbor Can #1 NVN #4 ?
13/May/1978				44°07'15.0" 69°00'48.9"			
13/May/1978				44°06'51.0" 69°00'26.0"			
17/Nov/1978			3143 / 4054				

+ Lost

TABLE 27B

SAMPLE LOCATIONS

SITE: Portland, Me.

	DISPOSAL SITE:				REFERENCE SITE		
			BENTHIC SAMPLES			BENTHIC SAMPLES	
DATE	CURRENT METER	MUSSELS	DREDGES	GRABS	MUSSELS	DREDGES	GRABS
15/Dec/1977	43°34'00.3" 70°01'58.4"		43°33'55" 70°02'25.5"	43°33'45.4" 70°01'50.7"			
18/May/1978	43°34'00.3" 70°01'58.4"	43°33'55.5" 70°01'58.3"	43°34'4.3" 70°01'44.0"		43°35'09.7" 70°03'51.3"		
19/Nov/1978	"BOLT" G 15457 R 23396				43°35'09.7" 70°03'51.3"		

TABLE 27C

SAMPLE LOCATIONS

SITE: Isle of Shoals, N.H.

DATE	DISPOSAL SITE: CURRENT METER	MUSSELS	BENTHIC SAMPLES DREDGES	BENTHIC SAMPLES GRABS	REFERENCE SITE MUSSELS	BENTHIC SAMPLES DREDGES	BENTHIC SAMPLES GRABS
20/May/1978	NO CURRENT METER INSTALLED		42°59'27.9" 70°32'35.2"		42°59'00" 70°36'00"		Portsmouth Harbor
5/Aug/1978					Smuttynose		
8/Dec/1978			42°58'50.0" 70°32'45.0"				
17/Dec/1977			?				
8/Dec/1978			42°58'40.0" 70°33'00.0"				

TABLE 27D

SAMPLE LOCATIONS

SITE: Boston Foul Ground

DATE	DISPOSAL SITE: CURRENT METER	MUSSELS	BENTHIC SAMPLES DREDGES	GRABS	REFERENCE SITE MUSSELS	BENTHIC SAMPLES DREDGES	GRABS
18/Dec/1977			42°25'21.8" 70°34'54.2"				
23/May/1978	42°25'41.9" 70°34'51.8"	42°25'45.2" 70°34'50.1"	42°25'39.9" 70°34'38.0"				
21,22/May/78					42°30'07" + 70°46'28"		
6/Dec/1978							

Same Ref. For Boston Lightship

TABLE 27E

SAMPLE LOCATIONS

SITE: Boston Lightship

DATE	DISPOSAL SITE: CURRENT METER	DISPOSAL SITE: MUSSELS	DISPOSAL SITE: BENTHIC SAMPLES DREDGES	DISPOSAL SITE: BENTHIC SAMPLES GRABS	REFERENCE SITE: MUSSELS	REFERENCE SITE: BENTHIC SAMPLES DREDGES	REFERENCE SITE: BENTHIC SAMPLES GRABS
22/May/1978					42°30'07" + 70°46'28"		
23/May/1978		42°21'17.0" 70°40'43.6"	42°21'19.2" 70°40'37.2"				
6/Dec/1978		42°21'17.6" 70°40'36.2"	42°21'20.8" 70°40'37.9"				
18/Dec/1977							

Same Ref. For Boston Foul

TABLE 27F

SAMPLE LOCATIONS

SITE: Brenton Reef

DATE	DISPOSAL SITE: CURRENT METER	DISPOSAL SITE: MUSSELS	DISPOSAL SITE: BENTHIC SAMPLES DREDGES	DISPOSAL SITE: BENTHIC SAMPLES GRABS	REFERENCE SITE MUSSELS	REFERENCE SITE BENTHIC SAMPLES DREDGES	REFERENCE SITE BENTHIC SAMPLES GRABS
11/Dec/1978			41°23'22.4" 71°18'25.2"			41°21'47.7" 71°19'39.9"	
30/June/1978					Green Bridge		
3/Aug/1978			41°22'16.5" 71°17'14.1"				
19/Apr/1978	41°23'24.3" 71°18'26.1"	41°23'27.1" 71°18'28.4"					
25/Apr/1978							

TABLE 27G

SAMPLE LOCATIONS

SITE: New London

DATE	DISPOSAL SITE: CURRENT METER	DISPOSAL SITE: MUSSELS	DISPOSAL SITE: BENTHIC SAMPLES DREDGES	DISPOSAL SITE: BENTHIC SAMPLES GRABS	REFERENCE SITE MUSSELS	REFERENCE SITE BENTHIC SAMPLES DREDGES	REFERENCE SITE BENTHIC SAMPLES GRABS
March/1978	41°16'04.8" 72°04'15.0"						
17/Apr/1978							
2/Aug/1978			41°16'23" 72°04'56"	~~Decca~~			
2/Aug/1978			41°15'51" 72°04'55"				
20/Sept/1978	G 5404 BOLT 41°16'6.2" R 8122 72°04'50.7"			41°15'42" 72°05'19" (F8)			
20/Sept/1978				41°16'33.5" 72°04'40.5" (F4)			
20/Sept/1978				41°17'09" 72°07'17" (C1)			
20/Sept/1978				41°16'38" 72°06'08" (C3)			
20/Sept/1978				41°16'23" 72°05'33.5" (C4)			
20/Sept/1978				41°16'08" 72°05'00" (C6)			
20/Sept/1978				41°15'52.5" 72°04'25" (C8)			
20/Sept/1978				41°15'37.5" 72°03'51" (C9)			

TABLE 27H

SAMPLE LOCATIONS

SITE: Cornfield

DATE	DISPOSAL SITE: CURRENT METER	MUSSELS	BENTHIC SAMPLES DREDGES	GRABS	REFERENCE SITE MUSSELS	BENTHIC SAMPLES DREDGES	GRABS
31/July/1978			41°12'32.2" 72°21'36.6"	No Posit.		41°13'32.2" 72°22'11.8"	
31/Jan/1978	41°12'43.3" 72°21'59.8"	41°12'37.4" 72°21'56.0"			41°13'44.1" 72°22'24.1"		

TABLE 27I

SAMPLE LOCATIONS

SITE: New Haven

DATE	DISPOSAL SITE: CURRENT METER	MUSSELS	BENTHIC SAMPLES DREDGES	GRABS	REFERENCE SITE MUSSELS	BENTHIC SAMPLES DREDGES	GRABS
13/April/78	41°08'55.9" 72°53'15.9"	41°08'59.1" 72°53'19.1"			41°09'18.5" 72°54'26.2"		
29/July/1978			41°08'47.5" 72°52'49.9"		41°09'13.3" 72°54'27.9"	41°09'21.8" 72°54'40.6"	

TABLE 27J

SAMPLE LOCATIONS

SITE: WLIS (Western Long Island Sound)

DATE	DISPOSAL SITE: CURRENT METER	MUSSELS	BENTHIC SAMPLES DREDGES	GRABS	REFERENCE SITE MUSSELS	BENTHIC SAMPLES DREDGES	GRABS
12/April/78	41°00'54.5" 73°21'18.6"	41°00'51.9" 73°21'16.5"			41°23'24.8" 73°23'52.3"		
26/July/78		Sample					
27/July/78			41°00'40.4" 73°21'01.8"			41°01'05.7" 73°23'56.7" +	

+ Same Ref. for CAB/ANC.

TABLE 27K

SAMPLE LOCATIONS

SITE: Cable and Anchor Reef

	DISPOSAL SITE:				REFERENCE SITE		
DATE	CURRENT METER	MUSSELS	BENTHIC SAMPLES DREDGES	GRABS	MUSSELS	BENTHIC SAMPLES DREDGES	GRABS
11/April/78	41°00'27.6" 73°26'10.0"	(?)	41°00'21.5" 73°26'14.5"			41°01'05.7" 73°23'56.7" +	
11/April/78			41°00'02.7" 73°26'47.6"				
11/April/78			40°59'19.7" 73°27'19.6"				
28/July/78							
12/April/78							

+ Same Ref. For WLIS